FOREST FIRE CONTROL IN WESTERN SNOHOMISH COUNTY, WASHINGTON

Progress Report on a Study of

Adequate Fire Control on Private Forest Lands

in the Douglas Fir Region of Washington and Oregon

Donald N. Matthews, Silviculturist
William G. Morris, Assistant Silviculturist

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FOREWORD

Adequate protection from forest fires is a necessary first step in the practice of forestry within the Douglas-fir region of Oregon and Washington. That this has been recognized is evidenced by the long-continued fire control effort within the region by both public and private agencies.

For many years the Pacific Northwest Forest and Range Experiment Station has conducted studies of fire control. These have principally pertained to the techniques of prevention, detection, and suppression of fires and the establishment of uniform methods of measuring fire danger. Through the work of numerous organizations, of which this Station has been but one, these techniques have reached a high degree of proficiency. Apparently there is now a tendency for the development of control techniques to proceed more rapidly than changes in fire control organization, including financing and administration. This is not through a lessening of effort or desire to give protection, but because financing and administration have tended to remain static amidst rapidly altering conditions of population and land use. These conditions demand better fire control which the public is apparently reluctant to finance.

At the request of its Advisory Council, the Experiment Station has undertaken a study of adequate fire control upon a selected unit of forest lands not in Federal ownership. The following report summarizes the results of this study. It is made available to the public in the hope that its findings may be of value in any reorganization of fire control effort which may seem advisable. It is also hoped that the method of analysis here established may be of use to other workers undertaking similar studies in other localities. The selection of Snohomish County as the sample unit and the conduct of the study were made in close cooperation with the State Supervisor of Forestry of Washington and the Washington Forest Fire Association. Much of the material here presented was made available by these organizations. The Experiment Station gratefully acknowledges their cooperation, realizing that the study would have been well-nigh impossible without their help.

The study confines itself to the mechanics and organization of adequate fire control within the area of State-owned and privately owned lands in Snohomish County. By this limitation it leaves many questions unanswered. Not the least of these is the economic justification for adequate forest fire control. The Experiment Station hopes that a study of this subject may be undertaken in the near future. An analysis of the costs of adequate fire control in relation to the returns to be expected from the growing of forests may aid the private owner in establishing long-time operations. It may also help to determine the proper relation between private and public interest in the financing of fire control on privately owned forest lands.

STEPHEN N. WYCKOFF,
Director.

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INTRODUCTION

In order to present the factual material and the interpretations and recommendations separately, the study of the sample area is divided into two parts:

I. Analysis of the fire control problem.

II. Specifications of adequate fire control.

These subjects will be discussed in that order.

Throughout this report the term "forest land" is used with the fire control meaning implied in the Washington and Oregon fire laws: Washington law (Sec. 220): ". . . any land shall be considered forest land which has enough timber, standing or down, or inflammable debris, to constitute in the judgment of the State Board of Forest Commissioners a fire menace to life or property." Oregon law (Sec. 42-403): ". . . forest land means and includes any forest, woodland, brushland, cut-over land, slashing, chopping, or clearing containing any inflammable forest debris . . ."

For the purposes of this report, whatever the use made of the land or the intent of the owner, if its present cover fits the above definition it is forest land, except that all lands classified as "cultivated" or "non-forest" (mostly barren or grass lands at high elevations) by the Forest Survey are kept in a separate category and not included with the forest land. Therefore the total gross land area within the unit falls into one of two classes: (1) Cities and towns, cultivated land, grass land, or barren land; (2) forest land; and this report is primarily concerned with the forest land.

Part I
ANALYSIS OF THE FIRE CONTROL PROBLEM

DESCRIPTION OF SAMPLE UNIT

This analysis applies to that part of Snohomish County, Washington, which is outside national forest fire protection boundaries and which comprises the Snohomish County unit of the State and the Washington Forest Fire Association. It includes a small acreage in Skagit County. The boundaries of this unit are shown on the cover.

It contains a gross area of about 670,000 acres not including the area in towns of over 1,000 population. The 1938 revised Forest Survey type map indicates that 546,000 acres of the gross area can be classed as forest land as herein defined, the remainder being practically all agricultural or barren land. The following description of Snohomish County has been taken from "Descriptive and Statistical Information of Washington", by the Washington Bureau of Statistics and Immigration, published by the Washington Secretary of State, vol. 3, 1938 edition, page 235:

> "Broad river valleys, rolling uplands and rough mountains are its characteristic features. The principal valleys are in the Stillaguamish and its two forks in the northern half of the county, and the Snohomish and the Skykomish in the southern half. These valleys broaden out near the Sound, and take in a large area of rich delta flats. The remainder of this western half of the county consists of rolling uplands spotted with swampy depressions and meadows studded with pretty lakes. Toward the east the timbered foothills gradually increase in altitude and ruggedness until the summit of the Cascade Mountains is reached in the eastern extremity [inside the national forest], where Glacier Peak, 10,436 feet above sea level, dominates the landscape. The soil of the river bottoms is rich and fertile and highly productive. Irrigation is unnecessary as the annual precipitation ranges from 30 inches near the Sound to 60 inches in the foothills. The average length of the growing season is about 180 days."

Everett, a forest products manufacturing center with several large sawmills, pulp mills, plywood plants, shingle mills, and other smaller plants using wood as a raw material, has a population of 29,975 (1940) and is located near the center of the western edge of the county on Puget Sound at the mouth of the Snoqualmie River, one of the two principal rivers. There are excellent ocean and railroad shipping facilities. It is the population center and an important forest products manufacturing center. Everett is only 30 miles from Seattle, and the southwest corner of the county contains suburbs of Seattle. The census (1930) reveals a striking density of population outside the two cities having a population of 2,500 or more and not on farms as follows:

Farm population	18,482
Rural non-farm population	27,202
Urban population	33,255
	78,939

About two-thirds of the rural non-farm population live away from the smaller towns. The importance of this rural non-farm population to fire control on the forest lands in certain parts of the county is discussed later in this report. The 1940 population of the county is 88,000, but the division among the above classes is not yet available.

This county was selected for study because it had been under a stabilized system of fire control for several decades and it appeared to

be fairly typical of the counties in which logging has been in active progress since the early 1900's. There are a number of counties in Washington and Oregon that have similar fire control problems. Cut-over lands, reforested and non-reforested, and intermingled settlement dominate the fire control problem because the virgin forest has shrunk until it is a small part of the total area involved. Another reason for selecting this county is that its forest lands have a high potential productive capacity and they are accessible to an excellent market for raw forest products, a combination which should make private forestry as profitable in Snohomish County as in any part of the Douglas-fir region. It should follow that a high standard of fire control can be justified on the basis of values protected.

LAND USE DISTRICTS

For purposes of analysis the Snohomish County unit has been divided into the four land use districts shown on the cover. The area in towns of over 1,000 population is excluded from this classification. These districts are separated one from the other on the basis of the present predominating use or condition of the land. There is no intent whatsoever to indicate or forecast what the future use will be or should be, because this is strictly an analysis of existing conditions. The districts were drawn on a Forest Survey cover type map; hence they represent a combination of cover types and certain additional considerations of density of population and land use. Each of the four land use districts will be described briefly.

Virgin Forest. This district contains the residue of natural, untouched forest land remaining in the unit. For the most part it is characterized by rugged topography. It includes heavy, valuable stands of merchantable timber, sparse, low value forests on precipitous rocky slopes, and the subalpine type and rocky barrens of the higher elevations. It is uninhabited and inaccessible except by trails and one road. The boundaries were drawn to make this district conform strictly to what its name implies. Detached remnants of virgin forest were included in the adjacent district.

Cut-over. That part of the unit which is predominately cutover and has few residents and a minor amount of agricultural development has been designated the cut-over district. This district is essentially a forest district, and it is characterized by easy topography and numerous solid blocks of clear-cut cut-over land left from former large scale railroad logging operations. It contains considerable reproduction up to 40 years old and large areas that have not restocked because of lack of seed supply, or because of repeated fires or because they have been cut over only a few years. The cut-over district contains practically all of the present logging operations in the unit. It includes several thousand acres of valuable old-growth timber in scattered patches. It contains a few farms, but in general the soils are not especially suitable for agriculture. Much of it is well served by highways and roads, but there

are remote corners served only by widely spaced CCC roads on old logging railroad grades.

Rural Residential. This district was drawn to include cut-over lands having a predominately forest cover and a high density of rural population. Agricultural use does not predominate. Much of the soil is gravelly and not productive for any form of agriculture; hence only a small percent of the area of the small tracts being lived upon has been cleared of stumps and forest growth. The district contains a few farms on the scattered spots of better soils. Unoccupied lands have a forest cover. Many of the residents work in Seattle, Everett, or elsewhere. The acreage that they live upon does not support them. This district is generally level or gently rolling, and is thoroughly crisscrossed with highways and roads; it is supplied with electricity; schools and stores are not far from any part of it. Owing probably to the combined effect of repeated fires and the absence of seed supply, a large part of this district is nonstocked or poorly stocked; however, there is considerable second growth, some of it large enough for pulpwood, poles, or small sawlogs.

Agricultural. As the name implies, this district is predominately devoted to agricultural use. Dairying is the principal type of farming. The best lands are in the river bottoms. About 37 percent of its gross area can be classed as having a forest cover as herein defined. Some of these forest lands were among the first in the county to be cut over, and they now have second-growth stands of Douglas-fir, hemlock, and alder approaching merchantable size.

Analysis of the Forest Fire Problem by Land Use Districts

The total gross area of the Snohomish County unit, exclusive of cities and towns, is divided among the four land use districts as follows:

Land use district	Area	
	Acres[1]	Percent
Virgin forest	139,000	21
Cut-over	241,000	36
Rural residential	158,000	23
Agricultural	132,000	20
	670,000	100

1/ All the acreage figures used in this analysis of land use districts and subsequent analyses of protection status and cover types are approximations based on the assumption that all sections contain 640 acres.

The forest land of the unit is divided among the districts as shown in table 1.

Table 1.--Division of forest land among land use districts

Land use district	Forest land		
	Area	Division between districts	Amount within each district
	Acres	Percent	Percent
Virgin forest	117,240	21	84
Cut-over	237,410	44	99
Rural residential	142,100	26	90
Agricultural	49,280	9	37
All districts	546,030	100	81

One of the striking features brought out by these figures is the high percentage of forest land in the agricultural and rural residential districts; 37 and 90 percent, respectively. In spite of their heavy present use for other than forestry purposes, these districts contain sufficient forest land to give them important fire control problems, and this fact is brought out in table 1. The virgin forest district contains 84 percent forest land; the remainder is mostly barren, rocky land at the higher elevations. The cut-over district is 99 percent forest land.

Table 2.--Summary of forest fire business is Snohomish County unit from 1935 to 1939, inclusive

Land use district	Items of fire business			
	Number of fires by districts		Area burned by districts	
	Number	Percent	Acres	Percent
Virgin forest	8	2	40	(0.3)
Cut-over	187	41	9,084	67
Rural residential	185	41	3,343	25
Agricultural	72	16	1,160	8
Total	452	100	13,627	100

Some indication of the volume of fire business by land use districts can be seen in the fact that 57 percent of the total number of fires in the Snohomish County unit during the five years from 1935 to 1939, inclusive, occurred in the rural residential and agricultural districts taken together (table 2). Only 2 percent occurred in the virgin forest district. Sixty-seven percent of the total area burned was in the cut-over district, 33 percent was in the rural residential and agricultural districts, and less

than 1 percent was in the virgin forest district. Table 3 draws another comparison of the fire business among the districts by showing how the size of fires varied.

Table 3.--Size classes of fires by land use districts in Snohomish County, 1935 to 1939, inclusive

Land use district	Size classes of fires			Total
	A - less than $\frac{1}{4}$ acre	B - $\frac{1}{4}$ to 10 acres	C - over 10 acres	
	Percentages by rows			
Virgin forest	38	50	12	100
Cut-over	34	43	23	100
Rural residential	25	63	12	100
Agricultural	38	46	16	100

The agricultural and virgin forest districts have the highest percent (38 percent each) of small fires of class A size (less than $\frac{1}{4}$ acre); the rural residential district has the highest percent (63 percent) of class B fires ($\frac{1}{4}$ acre to 10 acres); and the cut-over district has the highest percent (23 percent) of large fires of class C size (over 10 acres). Of the 8 fires which occurred in the virgin forest during the period studied, only 1 was of class C size.

The analysis up to this point might be summed up by stating that the agricultural and rural residential districts taken together contain 35 percent of the forest land in the unit, and in the five years 1935-39, inclusive, had 57 percent of the total number of fires and 33 percent of the total burned area. This statement is made in this way to focus attention on the fact that fire control in the Snohomish County unit is concerned with fires on all forest lands within the unit. The volume of fire business appears to be almost as great in the agricultural and rural residential districts as in the more strictly forest districts. How this distribution of fire business is related to ownership and, through ownership, to the financial support of fire control in the unit will be developed below.

PROTECTION STATUS

Ownership alone is a complete description of the protection status of State and national forest land. But private owners of forest land under the Washington forest fire laws may discharge their obligation to provide fire protection in one of four ways: (1) Live within one mile of the land. The law says: ". . . forest land shall be deemed to be adequately protected if within one mile of the owner's permanent residence." (This is called "residence exemption.") (2) Pay a special "fire patrol assessment" in addition to the property tax. (3) Delegate a private fire control organization such as the Washington Forest Fire Association to furnish fire protection satisfactory to the State Supervisor of Forestry. (4) The owner may

elect to furnish his own fire protection, but this is rarely done at present. For the purposes of this analysis all the forest lands in the Snohomish County unit have been placed in one of the following five protection status classes:

Association. Lands whose owners have an agreement to pay directly to the Washington Forest Fire Association for fire protection.

Tax Roll. Lands against which there is a "fire patrol assessment" on the tax rolls to be collected by the county and paid to the State which the State may, as in Snohomish County, contract to the Association for protection at the fire patrol assessment rate.

(Note: Owners with their lands in an Association or a tax roll protection status may be delinquent in their annual payments for several years without changing the protection status of their lands; hence the status of these lands indicates the owners' legal obligation to pay and is not intended to indicate whether or not they are actually paying, except that lands that have not paid for a number of years pass into the "non-paying" class. The distinction between "Association" and "tax roll" lands is mainly concerned with the manner of payment and the line of responsibility. The owners of both support the Association and the Association has the same responsibility for the protection of both.)

State. This includes lands of various categories (school, State forest, etc.) owned by the State.

National Forest. All Federally owned lands administered by the Forest Service fall into this category. The Snohomish County unit contains a considerable acreage (33,320 acres) because the national forest boundaries have been redrawn to exclude a block of national forest land for exchange that will eventually pass into State ownership. These exchange lands are inside the protection boundaries of the unit. Some of these exchange lands were still national forest land in 1938 and are included as such in this report. In addition there are a few locations outside the exchange area where national forest lands are included in the Snohomish County unit. This is in accordance with the common practice in Washington and Oregon of rounding out on logical administrative boundaries the division between the State and national forest fire control. By this arrangement private and State lands may be included in the national forest protection boundary and protected by the Forest Service in exchange for the protection of Forest Service lands inside the State units. The mutual arrangements for this exchange of protection are covered by a three-way agreement between the Forest Service, the State, and the Association.

Non-paying. All forest lands not included in the above protection status classes comprise this group. Probably the majority are tax delinquent lands in or passing into county ownership. It also includes the considerable acreage of private lands claiming residence exemption. The important feature is that these lands are not making any direct contribution to meet the cost of fire control.

The several protection status classes are widely scattered and thoroughly mixed together in this unit. There are no large concentrations

of any one class. The unit does not have any one large private owner. Many townships contain all five classes. National forest lands are confined to the eastern borders of the unit, but the other classes occur in practically every township.

Analysis According to Protection Status

Table 4 shows the protection status of the forest land in the unit.

Table 5 shows the same figures as in table 4 computed as percentages of the total forest land of each protection status. For example, reading the first column in the table, the total Association acreage is distributed among the land use districts as follows: Virgin forest 38 percent, cut-over 38 percent, rural residential 19 percent, agricultural 5 percent. The high percent of "non-paying" land in the rural residential and cut-over districts is a feature brought out by this table.

Table 6 shows the same data computed to show the percentage of each protection status in each land use district. For example, reading across the first row, the total forest land in the virgin forest district is distributed as follows: Association 28 percent, tax roll 8 percent, State 39 percent, national forest 19 percent, and non-paying 6 percent. Outstanding features brought out by this table are the presence of Association acreage in the agricultural and rural residential districts and the high percent of the forest land in the agricultural, rural residential, and cut-over districts that has a "non-paying" classification, which means that it is not making any direct contribution to meet the cost of fire control. The last row of figures in the table reveals that 41 percent of the total forest land is in this "non-paying" category.

These tables indicate where the Association gets its strongest support, where the majority of the tax roll, State, and non-paying lands are located, and the extent to which the forest lands in each land use district are supporting fire control.

ANALYSIS BY COVER AND FUEL TYPES

Cover Types

The Forest Survey cover types were grouped into four generalized cover types to classify the entire area of forest land in the Snohomish County unit. These are shown in figure 1. A brief definition of each of these four types is as follows:

Timber. Includes all old-growth and large second-growth timber of all species of conifers and hardwoods. Includes the subalpine forests at high elevations and the forests on steep rocky slopes. (Forest Survey types 6, 7, 8, 11, 14, 17, 23, 31.5, 33, and 38.)

Reproduction. All seedlings, saplings, and poles too small to be classed as "timber." (Forest Survey types 9, 10, 12, 13, 15, 16, 19, 24, and 31.)

Non-reforested. Forest Survey types 35, nonrestocked cutover

Table 4.--Protection status of forest land by land use districts, 1938 (acreages)

Land use district	Protection status					Total
	Association	Tax roll	State	National forest	Non-paying	
	Acres	Acres	Acres	Acres	Acres	Acres
Virgin forest	33,330	9,040	45,200	22,630	7,040	117,240
Cut-over	32,790	84,300	51,220	3,300	65,800	237,410
Rural residential	16,240	11,040	3,980	0	110,840	142,100
Agricultural	4,820	3,270	840	0	40,350	49,280
Total	87,180	107,650	101,240	25,930	224,030	546,030

Table 5.--Protection status of forest land by land use districts. Percentage of each protection status in each district (columns)

Land use district	Protection status				
	Association	Tax roll	State	National forest	Non-paying
	Percentages by columns				
Virgin forest	38	8	45	87	3
Cut-over	38	79	50	13	29
Rural residential	19	10	4	0	50
Agricultural	5	3	1	0	18
Total	100	100	100	100	100

Table 6.--Protection status of forest land by land use districts. Percentage of each district in each protection status (rows)

Land use district	Protection status					Total
	Association	Tax roll	State	National forest	Non-paying	
	Percentages by rows					
Virgin forest	28	8	39	19	6	100
Cut-over	14	35	22	1	28	100
Rural residential	11	8	3	0	78	100
Agricultural	10	7	2	0	81	100
All districts	16	20	18	5	41	100

clear cut prior to January 1, 1920; 35A, nonrestocked cutover clear cut from January 1, 1920 to December 31, 1929; 36, recent cutovers, clear cut and slash burned since January 1930; and 37, nonrestocked burns, not cut over. (Forest Survey types 35, 35A, 36 (burned), and 37.) Practically all of the non-reforested areas had been burned over.

Unburned Slash. Lands clear cut since January 1, 1930 and slash unburned in October 1939. (Forest Survey type 36, unburned.)

On the cover type map, figure 1, agricultural lands, barren rocky lands and other non-forest lands are designated with a special symbol.

Cover Types and Protection Status

Cover types are the key to several important considerations in fire control. They indicate where the present values are that need protection and which, in turn, should be able to give financial support to fire control. They indicate the type of fuels to be dealt with in the fire control job because, for example, timber fuels present a decidedly different fire control problem from the fuels on non-reforested lands. Therefore it is worth-while to study the cover types in the Snohomish County unit as part of the analysis of the fire control problem for the information they may reveal on the physical or engineering problems of fire control and the financial side of the problem.

The acreage figures in the last column of table 7 indicate that in 1938 there were 145,920 acres of timber, 232,510 acres of reproduction, 162,610 acres of non-reforesting lands, and 4,990 acres of unburned slash within the unit. This shows a strong preponderance of the reproduction and non-reforesting types and this is expressed in percentages in the last column of table 9, which shows that 42 percent of the forest land is reproduction and 30 percent is non-reforested land, while only 27 percent is timber and only 1 percent is unburned slash. The acreage of unburned slash indicates the annual accumulation from logging operations. Most of it is burned within one year after it is created. Nevertheless, unburned slash is far more important to fire control than its small acreage might indicate because it is the most dangerous fuel, and owing to its location it is subject to the special risk of the logging operations.

The first row of figures in table 8 indicates that 28 percent of the timber land gets its fire control by belonging to the Association, 13 percent is tax roll land, 33 percent is State land, and 16 and 10 percent are national forest and non-paying, respectively. As explained above, the exchange area tends to make a higher concentration of State lands in Snohomish County than would be found in most counties. Line 2 in table 8 shows that a very small part of the reproduction, 7 percent, belongs to the Association, only 20 percent is listed to pay a fire patrol assessment, and 60 percent is in the non-paying column, which means that the majority of the land with new forest growth is not making any contribution toward fire control. Line 3 in table 8 indicates that

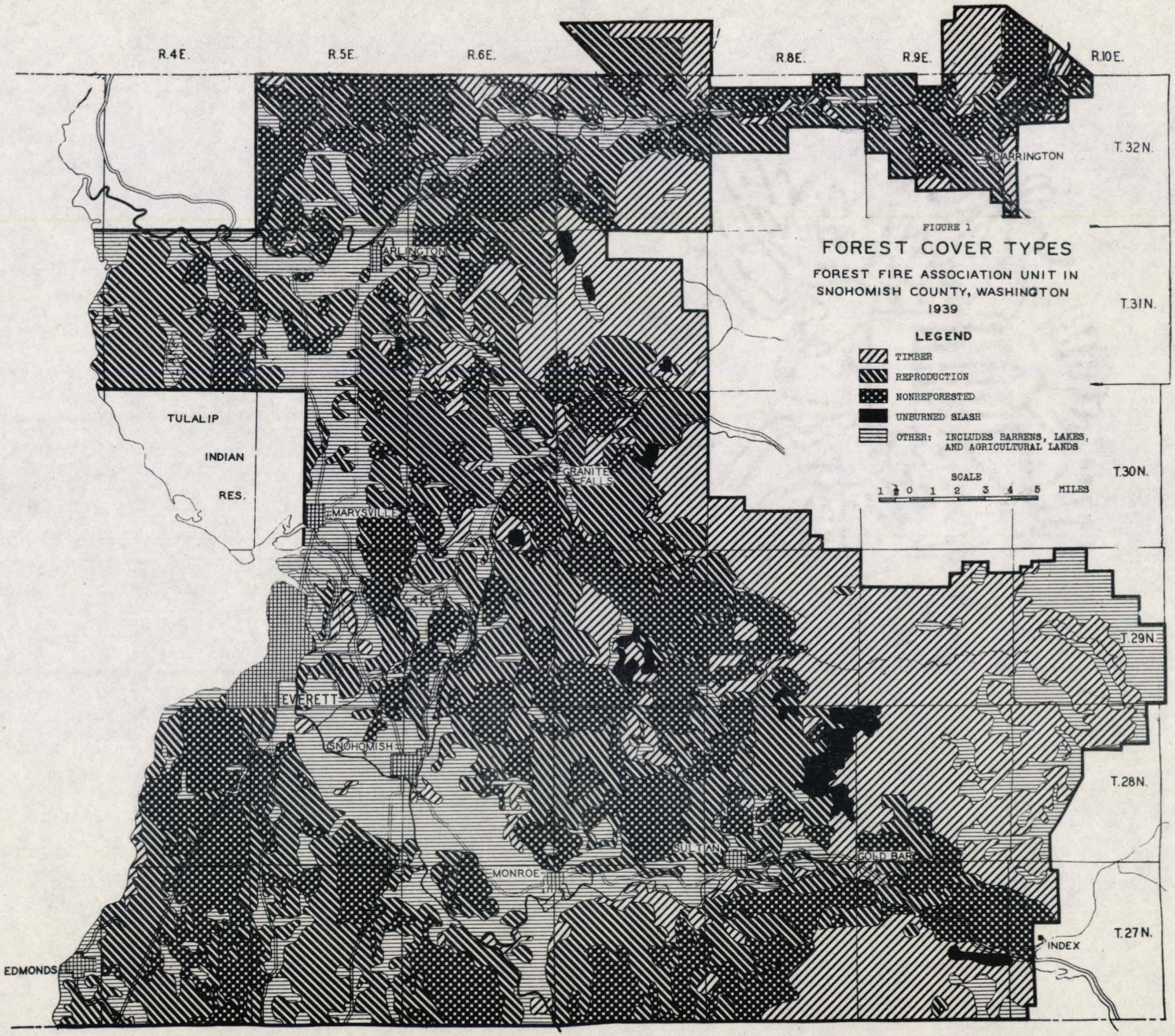

R.4E.
R.5E.
R.6E.
R.8E.
R.9E.
R.10E.
T.32N.
T.31N.
T.30N.
T.29N.
T.28N.
T.27N.
DARRINGTON
ARLINGTON
TULALIP
INDIAN
RES.
GRANITE FALLS
MARYSVILLE
LAKE
EVERETT
SNOHOMISH
SULTAN
GOLD BAR
MONROE
INDEX
EDMONDS
FIGURE 1
FOREST COVER TYPES
FOREST FIRE ASSOCIATION UNIT IN SNOHOMISH COUNTY, WASHINGTON
1939
LEGEND
TIMBER
REPRODUCTION
NONREFORESTED
UNBURNED SLASH
OTHER: INCLUDES BARRENS, LAKES, AND AGRICULTURAL LANDS
SCALE
1 0 1 2 3 4 5 MILES

Table 7.--Relation between cover types and protection status (1938) (acreages)

Cover type	Protection status					Total
	Association	Tax roll	State	National forest	Non-paying	
	Acres	Acres	Acres	Acres	Acres	Acres
Timber	40,700	18,380	48,810	23,230	14,800	145,920
Reproduction	16,800	46,130	29,870	750	138,960	232,510
Non-reforested	27,000	41,710	22,060	1,870	69,970	162,610
Unburned slash	2,680	1,430	500	80	300	4,990
Total	87,180	107,650	101,240	25,930	224,030	546,030

Table 8.--Relation between cover types and protection status. Percentage of each cover type in each protection status (rows)

Cover type	Protection status					Total
	Association	Tax roll	State	National forest	Non-paying	
	Percentages by rows					
Timber	28	13	33	16	10	100
Reproduction	7	20	13	--	60	100
Non-reforested	17	26	13	1	43	100
Unburned slash	54	29	10	1	6	100
All cover types	16	20	18	5	41	100

Table 9.--Relation between cover types and protection status. Percentage of each protection status in each cover type (columns)

Cover type	Protection status					All status classes
	Association	Tax roll	State	National forest	Non-paying	
	Percentages by columns					
Timber	47	17	48	90	7	27
Reproduction	19	43	29	3	62	42
Non-reforested	31	39	22	7	31	30
Unburned slash	3	1	1	--	--	1
Total	100	100	100	100	100	100

a somewhat larger percentage of the non-foresting lands have an Association or tax roll status than the reproducing lands. Many operating timber companies hold and protect their newer cut-over lands until they cut out, and this may explain why only 43 percent of these lands are in the "non-paying" status compared to 60 percent of the reproduction lands.

Probably a large part of the non-paying lands are tax delinquent. The extent of tax delinquency is revealed in Sinclair A. Wilson's "Facts Bearing Upon the Instability of Forest Land Ownership in Western Washington" (1934), in which it is shown that out of 352,527 acres studied in the forest area of Snohomish County in 1932, 5 percent had passed to county ownership by tax foreclosure, and 33 percent was tax delinquent three or more years.

In table 9 the cover types found within each protection status are shown. For example, column 1 shows that of the total Association acreage 47 percent is timber, 19 percent reproduction, 31 percent non-reforested, and 3 percent unburned slash. Column 2 shows that of the total patrol tax acreage 17 percent is timber, 43 percent is reproduction, 39 percent non-foresting, and 1 percent unburned slash. The State and national forest lands are 48 and 90 percent timber, respectively.

The proportion of cover types within each land use district is shown in table 10. The first column in the table, for example, shows that the forest land in the virgin forest district is 98 percent timber, 1 percent reproduction, and 1 percent unburned slash. It is important to note that the rural residential district contains a high percent of non-reforested lands and that the forest lands in the agricultural district are predominately classed as reproduction. The table shows 9 percent timber in the latter district. This is mostly large alder and large second-growth conifers.

Table 10.--Proportion of cover types on forest lands within each land use district (columns)

Cover type	Land use districts			
	Virgin forest	Cut-over	Rural residential	Agricultural
	Percentages by columns			
Timber	98	10	2	9
Reproduction	1	49	60	66
Non-reforested	0	39	38	25
Unburned slash	1	2	0	0
Total	100	100	100	100

The relation between cover types and fire control will be discussed in the next section.

Relation Between Cover Types and Fuel Types

In order to become thoroughly familiar with the unit and its cover and fuel conditions, one of the first steps in the analysis was to travel the roads in the unit and make a field translation of the Forest Survey cover type map (1938 revision) into fuel types. In this fuel type classification[2] cover conditions are viewed for their effect on the rate of spread of fire and upon the resistance to control or their effect upon the amount of work to be done to control a fire. Rate of spread is classed as being either zero, low, moderate, high, or extreme, with abbreviations of O, L, M, H, and X and with numerical values of 0, 1, 5, 25, 125, respectively. Thus a fire in fuels classed as having a moderate rate of spread will spread about 5 times as fast as in a low type. Resistance to control is classed as being either zero, low, moderate, high, or extreme, with abbreviations of O, L, M, H, and X, and with numerical values of 0, 1, 2, 4, 8, respectively. The two ratings are multiplied to get a numerical expression of the combined effect of both rate of spread and resistance to control. Thus an LL fuel type has a combined rating of 1, MM equals 10 (5 x 2), HH equals 100 (25 x 4), XX equals 1,000 (125 x 8), with corresponding values for the other combinations such as LM, ML, HX, etc.

Generalized fuel types are shown on figure 2. In this map the various possible combinations of rate of spread and resistance to control have been reduced to five broad classes of fuel hazard: Zero, low, moderate, high, and extreme. Therefore this map reveals a generalized picture of the variations in fuel conditions throughout the unit. Table 11 summarizes some of the more pertinent facts about the variation in fuel types by cover types. It shows that timber takes the lowest rating of any cover type and is followed up the scale by reproduction, non-reforested lands, and unburned slash in the order named.

Table 11.--Fuel types by cover types

Cover type	Predominant fuel types	Numerical value of predominant fuel types on a scale of 0 to 1000
Timber	85% LH	4
Reproduction	48% MM 31% LH	4-10
Non-reforested	77% MM	10
Unburned slash	61% HH 29% HX	100-200

The virgin forest district has the lowest rating because of its large acreage of timber rated LH and subalpine and barren, rocky areas at high elevations with a low or zero rating. The cut-over district presents a wide range of conditions; it contains nearly all the unburned

2/ U.S. Forest Service, North Pacific Region. Fuel Type Mapping. 1937. Mimeo.

slash; consequently it contains most of the area of top-level fuel types. However, it also contains considerable older reproduction having an MM or LH fuel type rating. So far as the effect of fuels on fire behavior and control is concerned, the particular spot in which a fire happens to occur in the cut-over district is extremely important. The fuel types in the rural residential district are largely dominated by those occurring on the large acreage of nonrestocked lands. These nonrestocked lands have been burned over many times since the timber was cut 20 to 40 years ago. They tend to have a cover of bracken, weeds, and light brush. The layer of fuel on the ground is thin, but it is exposed to the sun and wind and will dry out quickly and carry fire rapidly during any period of dry weather. Therefore the fire season in this district extends from February or March to late October. The length of the fire season is shortest in the virgin forest district because of the dense shade of the timber and the generally high elevation.

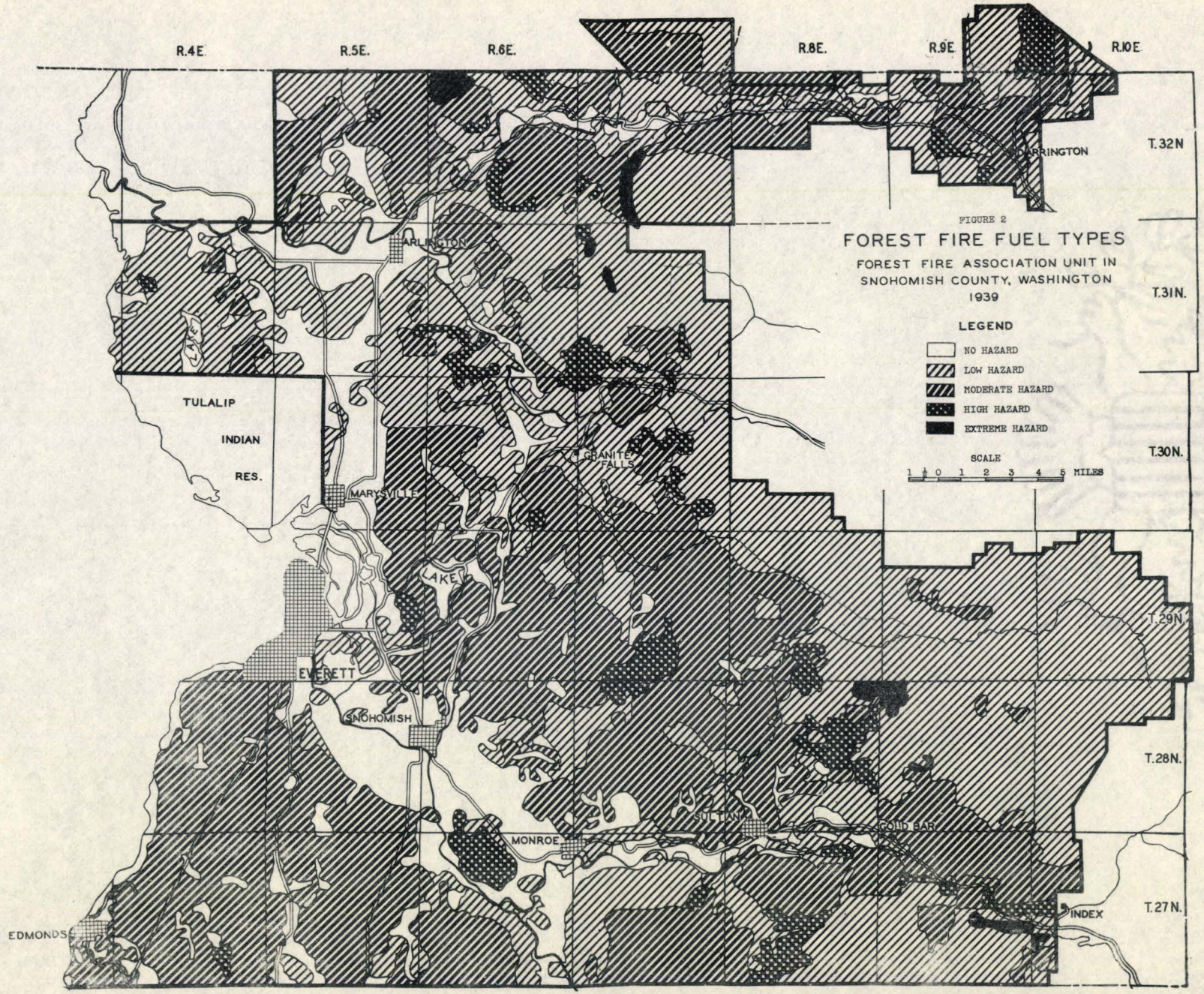
In the Snohomish County unit there appears to be no outstanding relationship between fuel type and protection status, although unburned slash, the most important kind of fuel, occurs almost entirely on lands contributing to the support of fire control. Association, tax roll, and non-paying lands appear to have a higher than average fuel condition, while State and national forest lands have a lower than average fuel condition.

The relation between fuel type and fire occurrence will be discussed under "Fire Occurrence."

FIRE HISTORY AND FIRE OCCURRENCE

In this and subsequent parts of the analysis the individual fire reports made out by the fire wardens are the principal source of information. It should be understood that these fire reports were accepted at their face value without any field checks being made or any correction factors being applied. Items obviously incorrectly reported were not used. To make any checks or corrections would have required a much more intensive type of study. One of the reasons for selecting the Snohomish County unit as the sample was that it had as complete and consistent records as any unit. Although the records could be more accurate and more complete, they suffice to show the major parts and trends of the fire control problem. If this report indicates some of the worth-while uses that can be made of fire records it may help to get better records in the future.

The following items were omitted from the analysis because of insufficient information in the fire records: (a) Time of origin; (b) strength of attack (number of men sent to each fire); (c) burning conditions; (d) fuel conditions, except as indicated by general cover conditions; (e) size on discovery (except indirectly in "size on arrival.")


R.4E.
R.5E.
R.6E.
R.8E.
R.9E.
R.10E.
T.32N
T.31N.
T.30N.
T.29N.
T.28N.
T.27N.
ARLINGTON
DARRINGTON
TULALIP
INDIAN
RES.
GRANITE FALLS
MARYSVILLE
LAKE
EVERETT
SNOHOMISH
MONROE
SULTAN
GOLD BAR
INDEX
EDMONDS
FIGURE 2
FOREST FIRE FUEL TYPES
FOREST FIRE ASSOCIATION UNIT IN SNOHOMISH COUNTY, WASHINGTON
1939
LEGEND
NO HAZARD
LOW HAZARD
MODERATE HAZARD
HIGH HAZARD
EXTREME HAZARD
SCALE
1 0 1 2 3 4 5 MILES

Fire History

The number of fires and the area burned per fire per year is shown in figure 3. The records in recent years are probably more complete than formerly; hence the slight increase in number of fires may not have any significance. Even allowing for recent more complete records, this graph does indicate a very pronounced decrease in average area burned in recent years. The area burned per year as shown by a moving average of five-year periods is shown in figure 4, which reveals a sharply decreasing burning rate from 1922 to the present. Logging was much more active and widespread prior to 1930 than since that time, and large fires in recently logged lands probably accounted for a considerable part of the large acreage in these earlier years. The fire history in Skagit and King Counties on the north and south of Snohomish County, respectively, was also studied. They show much the same trend as Snohomish County, which would indicate that its fire history is typical of northwest Washington.

Fire Occurrence

The location and size of all fires which occurred in the unit from 1935 to 1939, inclusive, is shown in figure 5. The number of fires and the area burned by causes are summarized in table 12.

The figures in table 12 indicate that incendiary fires burn the largest total acreage and have next to the largest average area per fire. Fires from logging operations have the largest average size but there are only a few of them. Smokers' fires are more numerous than any other kind, and in the aggregate they burn a large area but they are below average in size. Lightning is a minor cause of fire in this unit.

Some of the outstanding facts about the relation between fire occurrence and months or season of the year are summarized in table 13. Both April and May have more fires and much larger acreage burned than June. About one-fourth of the total number of fires and total area burned are in April and May together. This indicates that fire control measures should be in effect during all possibly dangerous weather during those months, especially at the lower elevations and in the more exposed fuel types which dry out early. The better record in June may be due to the annual vegetation which is making rapid growth about that time, adding its succulence to the average moisture content of the fuels and also shading the fuels beneath it. As might be expected, July and August have the largest number of fires and 52 percent of the burned acreage. One large fire in October out of a total of 3 distorts the figures for that month. September seems to be in about the same class with June. There were also records for a few fires which occurred before or after the April to October period but they were not used.

In table 14 the occurrence of fires and area burned by causes in the land use districts have been put on a comparable basis by computing them as rates per 100,000 acres of forest land. For example, if a district

Table 12.--Total number of fires, area burned by causes, and related data, 1935 to 1939, inclusive

Cause	Total number of fires	Total area burned 1/	Area burned per fire	Percent of total area burned	Largest fire	Month of largest fire
	Number	Acres	Acres	Percent	Acres	Month
Lightning	22	202	9	1	160	September
Incendiary	62	5,161	83	39	2,800	July
Campers	23	1,813	79	13	1,725	October
Smokers	167	2,424	15	18	1,740	August
Brush burning	81	1,941	24	14	400	August
Slashing	2	0	0	0	--	--
Logging	12	1,106	92	8	520	October
Railroad	19	30	2	0	--	--
Miscellaneous	64	950	15	7	450	July
All causes	452	13,627	30	100	2,800	July

1/ Total area burned by fires of one acre or larger.

Table 13.--Total number of fires, area burned by months, and related data, 1935 to 1939, inclusive

Month	Total number of fires	Total area burned 1/	Area burned per fire	Percent of total area burned	Largest fire	Cause of largest fire
	Number	Acres	Acres	Percent	Acres	Cause
April	60	1,819	30	13	2/200	Brush burning 2/
May	58	2,326	40	17	740	Incendiary
June	42	276	7	2	80	Smokers
July	106	5,081	48	37	2,800	Incendiary
August	151	1,589	11	12	1,740	Smokers
September	32	291	9	2	160	Lightning
October	3	2,245	748	17	1,725	Campers
All months	452	13,627	30	100	2,800	Incendiary

1/ Total area burned by fires of one acre or larger.
2/ Two fires same size and cause.

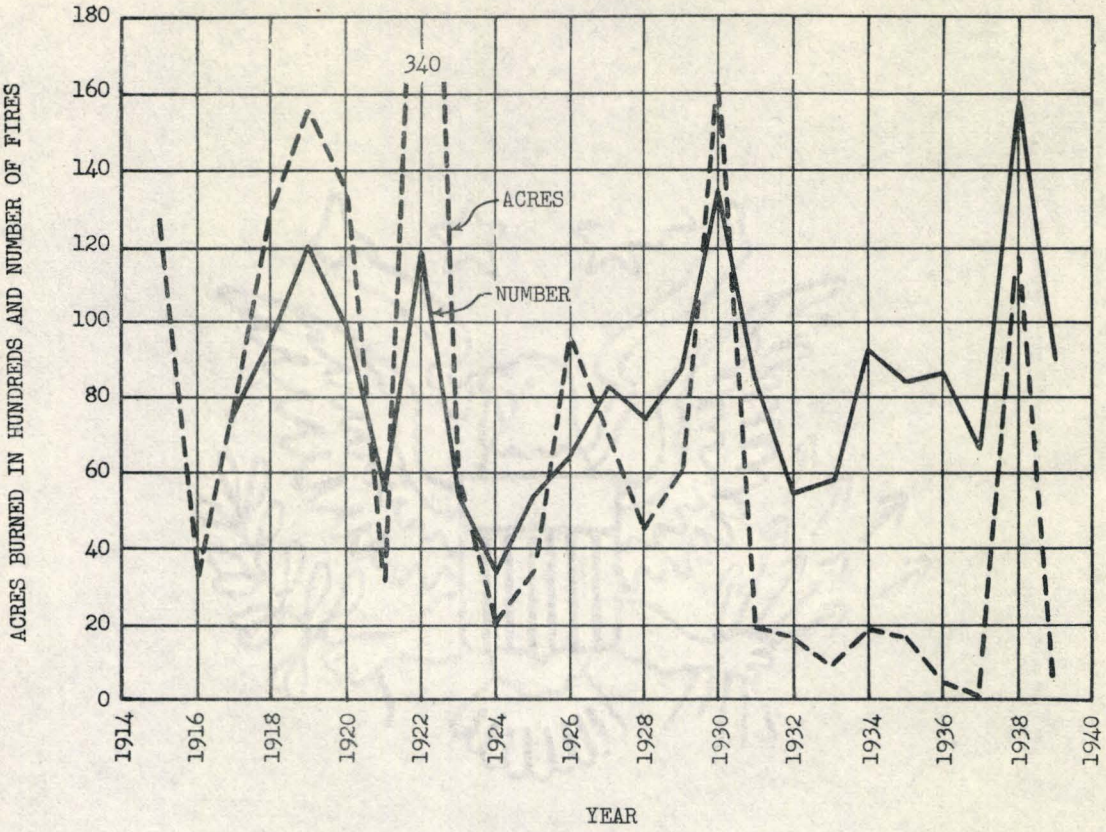


FIGURE 3.--ACREAGE BURNED AND NUMBER OF FIRES PER YEAR IN SNOHOMISH COUNTY

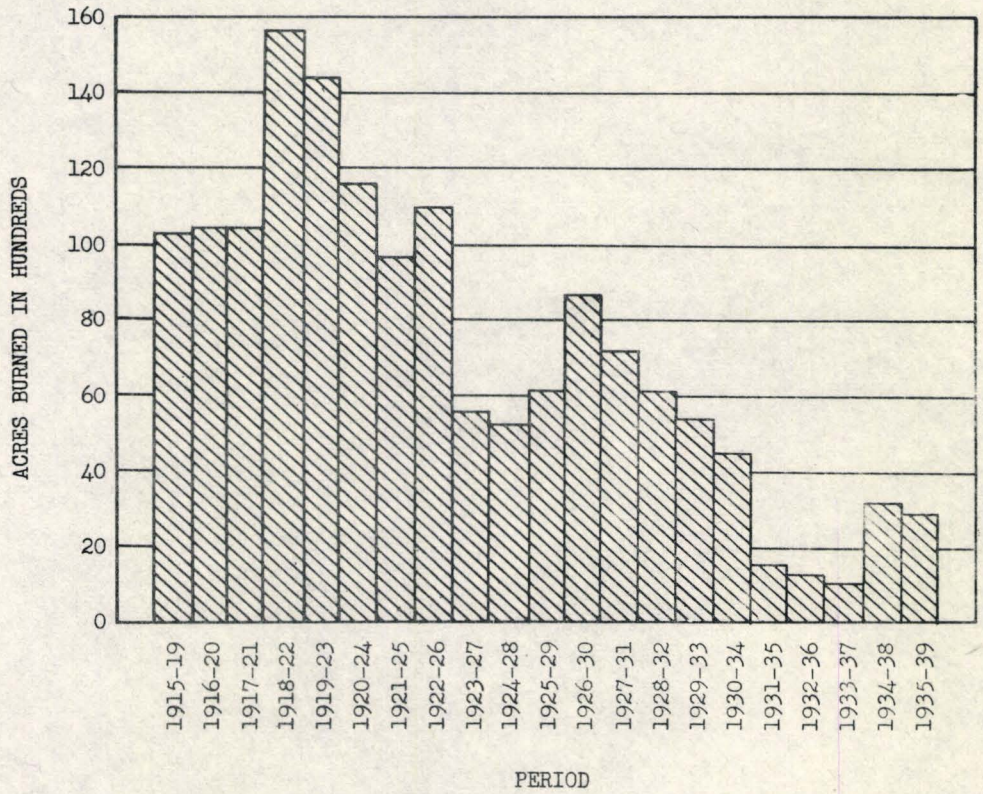


FIGURE 4.--AVERAGE ACREAGE BURNED PER YEAR BY 5-YEAR PERIODS

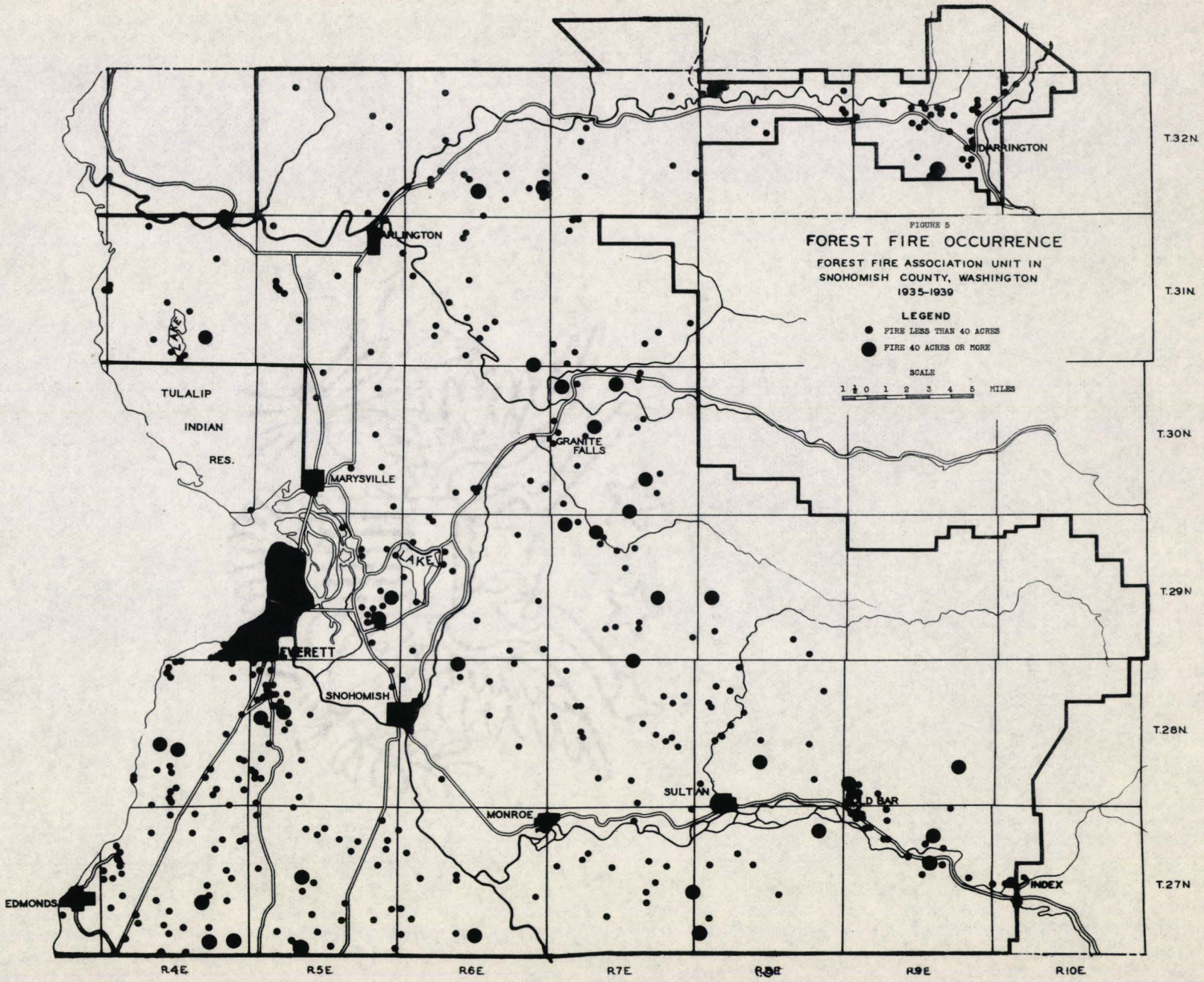


FIGURE 5
FOREST FIRE OCCURRENCE
FOREST FIRE ASSOCIATION UNIT IN
SNOHOMISH COUNTY, WASHINGTON
1935-1939
LEGEND
FIRE LESS THAN 40 ACRES
FIRE 40 ACRES OR MORE
SCALE
1 ½ 0 1 2 3 4 5 MILES
DARRINGTON
ARLINGTON
LAKE
TULALIP
INDIAN
RES.
MARYSVILLE
GRANITE
FALLS
LAKE
EVERETT
SNOHOMISH
SULTAN
D BAR
MONROE
INDEX
EDMONDS
T.32N.
T.31N.
T.30N.
T.29N
T.28N.
T.27N
R4E.
R5E.
R6E.
R7E.
R8E.
R9E.
R10E.

had 10 fires which burned a total of 400 acres out of a total area of 200,000 acres of forest land, the rate would be 5 fires and 200 acres per 100,000 acres. This method of presentation helps in making comparisons. For example, table 14 shows 0, 11, 29, and 29 fires caused by brush burning per 100,000 acres of forest land in the virgin forest, cut-over, rural residential, and agricultural districts, respectively. Immediately it is plain that the highest rate of occurrence of brush burning fires is in the rural residential and agricultural district, and since brush burning fires are largely controlled by permit it suggests what to do about them. Comparisons can be made between all the figures as well as within each column and row of figures in the table because they are all computed as rates per 100,000 acres of forest land.

Table 14.--Total number of fires per 100,000 acres of forest land and area burned (by fires one acre or larger) per 100,000 acres of each land use district by causes in the Snohomish County unit from 1935 to 1939, inclusive

Cause	Land use districts								All districts	
	Virgin forest		Cut-over		Rural residential		Agricultural			
	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres
Lightning	4	33	5	68	3	1	2	0	4	37
Incendiary	1	0	12	1,571	18	994	16	37	11	945
Campers	0	0	6	761	5	3	4	0	4	332
Smokers	2	1	23	240	57	1,029	59	791	31	447
Brush burning	0	0	11	450	29	136	29	1,377	15	356
Slash burning	0	0	1	0	0	0	0	0	0	0
Logging	0	0	5	466	1	1	0	0	2	202
Railroad	0	0	5	12	2	1	6	0	4	6
Miscellaneous	0	0	11	256	15	185	30	122	12	171
Total	7	34	79	3,820	130	2,350	146	2,327	83	2,496

Table 14 indicates that fires tend to spread to the largest size in the cut-over district. This district contains the fastest burning fuels, principally because timber harvesting is most active in it. The large size of fires in this district tends to give weight to the common observation that the period of timber harvest and the years following until a forest is again in complete possession of the ground are a special fire control problem that demands special treatment. During this period the kind, condition, and exposure of fuels tend to be favorable to rapid spread of fires of all causes.

The total number of fires and the total area burned (by fires of one acre or larger) per 100,000 acres of each cover type within each land use district during the five-year period studied is shown in table 15. This table provides a ready means for comparing the fire occurrence and burning rate of each cover type in each district. Although the rates for unburned slash were of necessity based on the

October 1939 acreage of that type mapped with the fuel types, which may not truly represent the average for the period, nevertheless this type undoubtedly has much higher occurrence and burning rates than any other. The non-reforested type has high rates in all districts where it occurs. The rates per year can be obtained by dividing all the values in the table by five.

Table 15.--Total number of fires and area burned (by fires one acre or larger) per 100,000 acres of each cover type within each land use district in Snohomish County unit, 1935 to 1939, inclusive

Cover type[1]	Land use districts								Average for the cover type	
	Virgin forest		Cut-over		Rural residential		Agricultural			
	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres
Timber	3	8	4	43	111	0	45	0	7	13
Reproduction	103	3,090	59	704	110	1,170	95	1,805	83	1,040
Non-reforested	0	0	88	4,810	157	4,080	220	4,280	121	4,520
Unburned slash	366	122	787	91,400	5,000	174,000	0	0	802	79,500
Average for the district	7	34	78	3,825	130	2,353	146	2,352	83	2,495

1/ Fires were counted according to the principal cover type involved. The area of a few large fires was tallied under two or more cover types.

Similar comparable occurrence and burning rates have been included showing rates by months in each district (table 16). This table indicates that August has the highest occurrence rate but that July has the highest burning rate. April and May have higher rates than June or September in all except the virgin forest district. One large fire in October distorts the rate for that month. The rural residential and agricultural districts have the highest occurrence rates but the cut-over district has the highest burning rate.

Table 16.--Total number of fires per 100,000 acres of forest land and area burned (by fires one acre or larger) per 100,000 acres of each land use district by months in Snohomish County unit, 1935 to 1939, inclusive

Month	Land use districts								All districts	
	Virgin forest		Cut-over		Rural residential		Agricultural			
	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres
April	0	0	16	377	10	205	16	1,284	11	333
May	0	0	13	498	15	794	10	32	10	426
June	2	0	11	48	7	108	8	16	8	51
July	2	1	12	1,505	40	807	37	730	19	930
August	0	0	21	368	46	406	73	284	28	291
September	3	33	4	84	12	33	2	6	6	53
October	0	0	1	945	0	0	0	0	1	411
All months	7	34	78	3,825	130	2,353	146	2,352	83	2,495

Fire Occurrence and Roads. The relation between the location of fires and roads is an item of importance. Basically it is people and not roads that start fires but the penetration of people into forest land seems to be so closely related to roads that they can be used to show the effect of human use on fire occurrence. The fire reports recorded the distance each fire started from a road. According to the summary of these entries (table 17) 56 percent of the man-caused fires occurred within 100 feet of a road, although a much smaller percentage of the total area is so located, and 88 percent occurred within 1/4 mile, and 99 percent occurred within one mile of a road. From these figures several important conclusions can be drawn: (a) Control of the public should be pointed toward roadsides; (b) patrols might be effectively used to discover fires; (c) the traveling public can see and make first report on many fires; (d) hazard reduction should be intensified along roads; (e) the unit is apparently well supplied with roads for suppression purposes; and (f) tank trucks might be used effectively in fire suppression.

Since fire occurrence is so closely related to roadsides, it follows that it may be also closely related to road mileage. Therefore it may be significant that the virgin forest district has only about 12 miles of roads and 1 fire; the cut-over district has 120 miles of roads and 16 fires, and the rural residential district has 250 miles of roads and 26 fires per 100,000 acres per year. Figure 6 shows the roads in the unit.

Table 17.--Percentage of man-caused fires starting at different distances from roads

Distance from road	Percentage of fires
0-100 feet	56
101 feet-1/4 mile	32
1/4-1 mile	11
Over 1 mile	1
Total	100

Fire Occurrence as Related to Weather. The $\frac{1}{2}$" x $\frac{1}{2}$" fuel moisture indicator stick records for July and August, 1935 to 1939 inclusive, at Darrington at the extreme northeast corner of the unit were used as an index of the fire weather conditions in the unit. These sticks are not in an ideal location to sample average conditions in the unit, but they were all that were available. Comparing the stick records with the fire occurrence records, it was found that days when the sticks had a minimum moisture content of 10 percent or less average one fire per day, days with minimum stick moisture contents of 11-15 percent averaged one fire in 3 days, and days with minimum stick moisture contents of 16 percent or over averaged one fire in 5 days. Furthermore, on days with minimum

stick moistures of 10 percent or less there occurred 100 percent of the days with 4 or more fires (there were 10 such days), 94 percent of the days with 2 or 3 fires per day, and 80 percent of the days with one fire per day. Also, 86 percent of all days with fires had a minimum stick moisture content of 10 percent or less, and 60 percent of the days with such sticks had fires.

BURNING PERMITS

These are another important item in the analysis of the fire control problem in Snohomish County. The State law requires: "No one shall burn any forest material . . . during the period beginning the fifteenth day of April and ending on the fifteenth day of October in each year, unless a different date for such beginning and ending is fixed by proclamation of the governor, which period is hereby designated as the closed season, without first obtaining permission in writing from the supervisor of forestry, or a warden, or a ranger, and afterwards complying with the terms of said permit; . . . The supervisor of forestry, any of his assistants, any warden or ranger, may at his discretion, refuse, revoke or postpone the use of permits to burn when such act is clearly necessary for the safety of adjacent property."

There were 1,330 burning permits issued in the Snohomish County unit during the 1939 season. This indicates the volume of business. Issuing and checking these permits takes considerable time. It is a potent means of controlling the use of fire and of preventing fires and fire losses. Most of the permits are issued in the early part of the season. The majority involve small operations--burning a single pile of refuse, a few stumps, or a small area of land clearing. A few permits cover the disposal of logging slash involving large acreages. The distribution of burning permits in 1939 by land use districts was as follows:

Virgin forest district	0	percent.
Agricultural "	21	" .
Rural residential "	59	" .
Cut-over "	20	" .
	100	" .

Since 80 percent of the burning permits are issued in the agricultural and rural residential districts in combination, they contribute a considerable part of the work load in those districts.

ORGANIZATION

The distribution of men within the unit in 1939 is shown in figure 6. In addition, there are several lookouts outside the unit in several directions and not shown on the map that give detection service. The District Warden's headquarters are at Sultan, and his assistant and one or two additional men work out of there also. A State CCC camp is

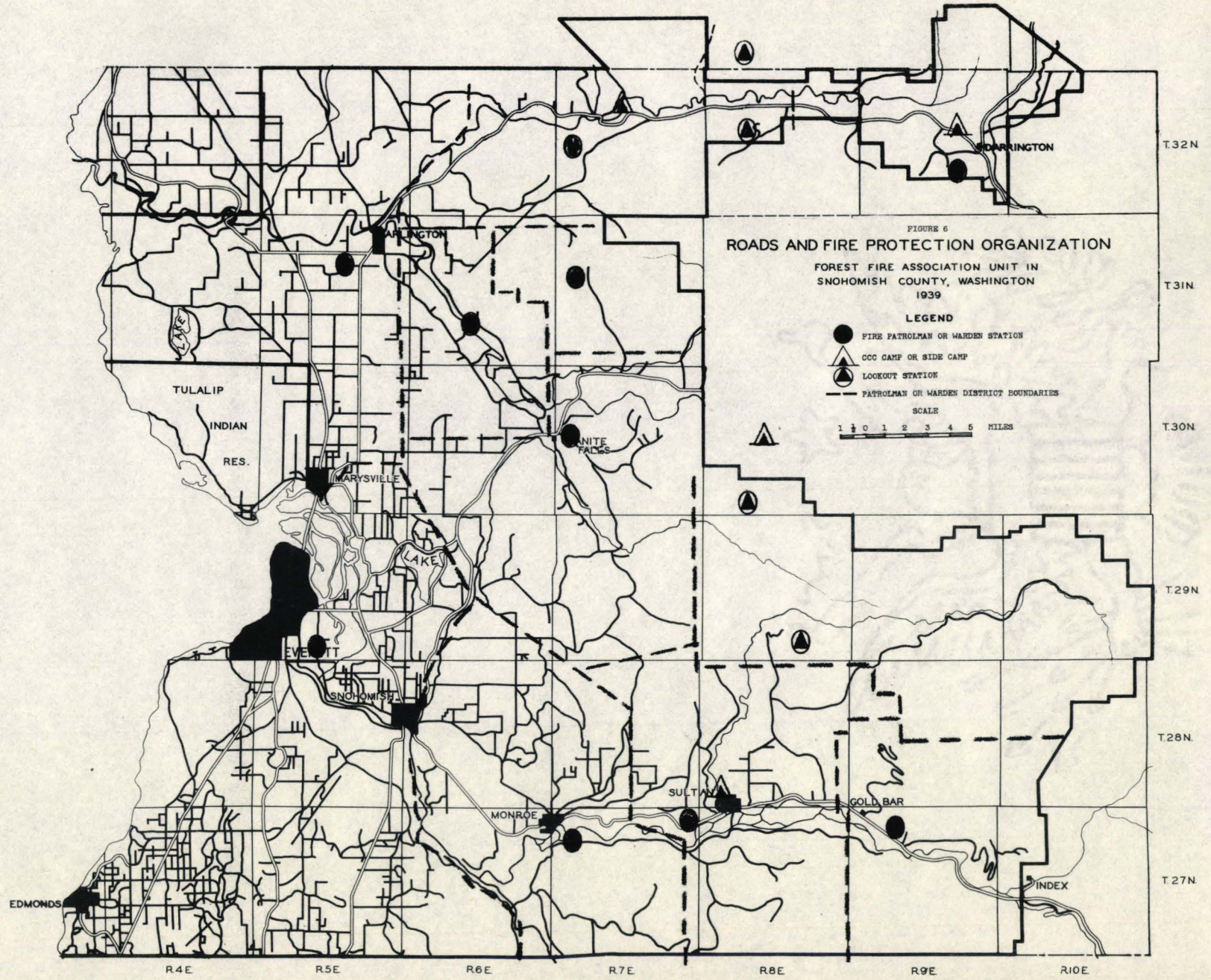


FIGURE 6
ROADS AND FIRE PROTECTION ORGANIZATION
FOREST FIRE ASSOCIATION UNIT IN
SNOHOMISH COUNTY, WASHINGTON
1939
LEGEND
FIRE PATROLMAN OR WARDEN STATION
CCC CAMP OR SIDE CAMP
LOOKOUT STATION
PATROLMAN OR WARDEN DISTRICT BOUNDARIES
SCALE
1 0 1 2 3 4 5 MILES
DARRINGTON
ARLINGTON
LAKE
TULALIP
INDIAN
RES.
GRANITE FALLS
MARYSVILLE
LAKE
EVERETT
SNOHOMISH
SULTAN
GOLD BAR
MONROE
INDEX
EDMONDS
T.32N.
T.31N.
T.30N.
T.29N.
T.28N.
T.27N.
R4E.
R5E.
R6E.
R7E.
R8E.
R9E.
R10E.

also located at Sultan with a side camp at Oso. These are the principal sources of CCC labor used on fires in the district, but the Forest Service CCC camp at Darrington and the side camp at Verlot are also sources of fire fighters. The subdistricts shown in figure 6 are assigned to one or more men with headquarters as shown.

During the period studied the District Warden and his assistants were on duty from April to the middle of October. They were also on call for pre- and post-season fires. Other members of the organization were employed for shorter periods. During the height of each season about 20 men were employed exclusive of fire fighters. Extra men were put on in the berry season to prevent berry picker fires. A girl was employed to write burning permits in Everett. An inspector and law enforcement officer spent about one-third of his time in this unit.

There is one field organization in the unit serving both the State and the Association. In recent years the State has paid somewhat more than half of the total salaries and expenses of the field force. Federal Clarke-McNary funds and general appropriations were used for this purpose by the State. The Association paid the remainder from assessments levied on its members and from the tax roll assessments which it received through contract with the State. County lands, tax delinquent lands, and lands with residence exemption did not contribute although they were a considerable part of the total forest land protected.

There is only one lookout in the unit. There are several State lookouts in adjacent units and several lookouts on near-by national forest lands that give detection service to the Snohomish County unit. However, the Forest Service lookouts are manned during a shorter season than those belonging to the State.

The District Warden has telephone communication with all members of his organization and adjacent lookout points. Commercial lines are used within the unit for the most part. Telephone routes to some of the lookout points outside the unit are roundabout and it is necessary to go through one or more switchboards so that it is not possible to talk direct from Sultan to all of the lookouts who serve parts of the unit.

Very few fire fighters have been hired in recent years. The wardens and their assistants handle small fires alone. The CCC crews help with larger fires and several wardens may be shifted to a large fire. Some of the reasons why few fire fighters are hired are explained under the next heading.

DIVISION OF RESPONSIBILITY FOR FIRE CONTROL

An analysis of fire control in the Snohomish unit or any other unit in Washington or Oregon would be incomplete without a statement about the division of fire control responsibility between the land owners and operators and the State. The Washington Forest Fire Laws (Sec. 214) place the basic fire control responsibility on the land owners:

"Every owner of forest land in the state of Washington shall furnish or provide therefor, during the season of the year when there is danger of forest fires, adequate protection against the spread of fire thereon or therefrom which shall meet with the approval of the state board of forest commissioners: Provided, however, That for the purposes of this section forest land shall be deemed to be adequately protected if within one mile of the owner's permanent residence or if the owner shall furnish patrol and protection therefor equal in standard, efficiency and seasonal duration to that of those who are in good faith maintaining organized patrol and protection of their lands against fire with the approval of the state board of forest commissioners. . ."

It is further provided (Sec. 215):

"If any owner or owners of forest land neglect or fail to provide adequate fire protection therefor as required by section 214 then the state supervisor of forestry . . . shall provide such protection therefor at a cost not to exceed five (5) cents per acre per annum. . ."

Owners and operators are also responsible for fire fighting under the conditions set forth in the law (Sec. 5806):

"Any fire on any forest land in the State of Washington burning uncontrolled and without proper precaution being taken to prevent its spread is hereby declared a public nuisance by reason of its menace to life or property. Any person, firm or corporation responsible for either the starting or the existence of such fire is hereby required to control or extinguish it immediately, without awaiting instructions from a forest officer, and if said responsible person, firm or corporation shall refuse, neglect or fail to do so, the supervisor of forestry or any fire warden or forest ranger acting with his authority, may summarily abate the nuisance thus constituted by controlling or extinguishing the fire and the cost thereof may be recovered from said responsible person, firm or corporation by action for debt and, if the work is performed on the property of the offender, shall also constitute a lien upon said property. . .

"When a fire occurs in a logging operation, such fire shall be fought to the full limit of available employees, as may be necessary, and such fire fighting shall be continued with the necessary crews in such numbers as are, in the opinion of the state forester, or his authorized deputies, sufficient to bring such fire to a patrol basis, and such fire shall not be left without such fire fighting crew or fire patrol until authority so to do has been granted in writing by the supervisor of forestry, or his authorized deputies."

It is the plain intent of these laws that the State shall take certain important fire control action only after the land owners or operators have failed to take action themselves.

Full appreciation of this placement of fundamental responsibility is necessary in order to understand the administration of fire control in the unit. The law makes the owner of the land or his agents responsible for fire control. They may delegate some of this responsibility to the State by paying the fire patrol assessment or to an Association by becoming a member, but under the law these agencies can relieve them of only a part of their responsibility. These agencies can assume a land owner's responsibility for protecting the normal hazard from fires for which he or his agents are in no way responsible, but they do not relieve the land owner or his agents of responsibility for fire control if they are in any way responsible for the origin of the fire, including fires set under permit, or if the fire originates in an active or inactive woods operation where the special hazard created by the operation has not been abated and the area accepted as a normal hazard by the State Supervisor of Forestry. Under the law the land owner may elect to protect his own land and carry full responsibility for all fire control activity.

To understand more fully the evolution of the laws into their present form it should be appreciated that originally almost all fire control was in the hands of the private owners and operators, and associations were, as their name implies, formed to perform owners' functions more effectively by cooperative effort. Fire protection for high value merchantable timber was the principal concern. Fire control for merchantable timber through cooperative effort was, in general, very successful and constitutes a fine example of what can be accomplished in that manner. Nevertheless, as indicated by the figures presented in this analysis, as the timber was cut conditions changed. The protection of merchantable timber has become a minor part of the total fire control job. Protection of cut-over lands has become the big job. Cut-over lands have a low present value; they tend to slip from private ownership with the end result that their protection tends to become a public responsibility. This statement is supported by the fact that at the time of the study but 16 percent of forest land belonged to the Association, an additional 20 percent was on the tax roll and all the remainder or 64 percent was either in public ownership, Federal, State, or county, or it was not making any contribution for fire control. Nevertheless, it is in the public interest to give all forest lands fire protection, and gradually State responsibility for fire control has increased.

The fact that the fire control agency, whether it is the State or the Association, assumes only such responsibilities as are delegated to it by the owners of specific lands or as are accepted by the agency under the law, leads inevitably to certain complications in the administration and financing of fire control. The situation is relieved somewhat by the fact that all law enforcement is vested in the State. If the owner or his agent fails to meet his responsibility the State may step in, take whatever action is necessary, and make the cost a lien against the

property. However, this very provision of the law indicates that the full, direct responsibility for fire control action does not rest on the State. The advantages and disadvantages of this division of responsibility appear to be about as follows:

Advantages

Self-interest tends to make an owner or operator do his best to save his own property from damage by fire and to avoid liability for the damage his fire may do to adjacent property.

Strong owners and operators may take strong action, possibly stronger action than the fire control agency might be able to take.

It tends to put the financial burden of fire control on the private owners and operators directly concerned instead of shifting it onto all the taxpayers of the State.

Placing fire control responsibility on the owners and operators has the psychological effect of making them directly interested in fire prevention, presuppression, and suppression.

It tends to develop initiative and resourcefulness in fire control matters in the people who are likely to be closest to a fire when it starts and so have the first opportunity to put it out. It gives fire control training and experience to large numbers of people.

Disadvantages

The action that is taken tends to be dependent upon the strength of the responsible owner or operator instead of on the needs of the situation. Strong owners and operators tend to take strong prevention, presuppression, and suppression action but weak owners and operators tend to take weak action.

Few operators are equipped, manned or trained to handle fires as effectively as a strong fire control agency.

Owners and operators tend to be most interested in saving their own timber, logs, bridges, machinery and buildings when a fire occurs and are not so interested in saving adjacent properties.

It places a heavy financial burden on the particular owner or operator who may happen to have a fire without providing any way whereby he can meet the cost. It subjects him to unpredictable costs which may wipe out all of his assets in fighting a fire in which the surrounding property and the public may have considerable interest. The hazards involved in logging operations are such that fire control costs for adequate action on any but the smallest fires amount to large sums of money and the small logger cutting 40 acres on a shoestring may not be able either to pay the costs of adequately fighting a fire in his slash or

to pay for the damage it may do to adjacent property.

If the State withholds action until the owner or operator responsible for action on a fire has ample opportunity to demonstrate his inability to put the fire out the fire may become more costly to all concerned and the loss of life and property may be greater than if the State had taken action in the beginning. If the State takes strong action on an operator's fire it must either collect the cost from the operator with all the trouble and litigation that may involve or pay the cost from State funds.

It tends to divide the responsibility for fire control action, and this may lead to delayed or weak action which will increase the costs and damage.

ANALYSIS OF DETECTION

Only 8 percent of the fires in the unit from 1935 to 1939, inclusive, were discovered first by lookouts. Patrolmen found 42 percent and "others", which includes the public or anyone except regularly employed lookouts or patrolmen discovered 50 percent of all fires. The close association between fires and roads, already mentioned (table 16), may explain why patrolmen and the public make first discovery on such a large proportion, 92 percent of all fires. The lookouts seldom discover fires in the rural residential or agricultural districts where roads are most numerous and the population is densest. They discover 14 and 22 percent of the fires in the cut-over and virgin forest districts, respectively. The size of the fires they discover does not appear to be larger or smaller than those discovered by anyone else.

The seen areas and blind areas of the present lookout detection system are shown in figure 7. These are based on a radius of about 15 miles from each point serving the unit. About 70 percent of the cut-over district is covered by lookouts when they are all at their stations. This is a high percentage of coverage. One possible weakness in the detection system is the length of time the lookouts are employed. Further study should be made to determine if it would be desirable to have them on duty during dangerous weather earlier and later each year and to determine if one or two additional points should be used to fill in when the smoke or haze reduces the effective range of present lookouts or to cover especially dangerous fuels.

ANALYSIS OF TIME ELEMENTS OF FIRE CONTROL

The speed-of-attack records on the fire reports for 1935 to 1939, inclusive, were analyzed. These were broken down into the customary units--report time, get-away time, travel time, etc. Many of these analyses did not appear to yield anything of sufficient importance to include here. However, the analysis of elapsed time from discovery to start of work (table 18) is included because it reveals important facts

about the speed of attack. The figures in the table show that most of the fires received prompt attention after they were discovered; hence report time, get-away time, and travel time must have been short. Of the fires discovered by patrols (42 percent of all fires were discovered by patrols) 48 percent were worked upon within 15 minutes, 62 percent within 30 minutes, and 83 percent within one hour after discovery; and all fires reported by patrolmen received attention before 24 hours had elapsed. Of the fires reported by others (58 percent of all fires), which includes lookouts, residents, travelers, and everyone except regularly employed patrolmen, 2 percent were worked upon within 15 minutes, 14 percent within 30 minutes, 40 percent within one hour, and 72 percent within two hours after they were discovered. Only about one percent had an elapsed time from discovery to start of work of more than 24 hours. As mentioned before, these figures show that report time, get-away time, and travel time, which are included in the time from discovery to start of work, must also have been short.

Table 18.--Elapsed time from discovery to start of work, April to October, 1935 to 1939, inclusive

Time	Discovery agency		
	Patrol	Other	All agencies
	Percent	Percent	Percent
0-15 minutes	48)	2)	19)
16-30 "	14) 83%	12) 40%	12) 55%
31-60 "	21)	26)	24)
1+ - 2 hours	7	32	23
2+ - 6 "	6	17	13
6+ - 24 "	4	10	8
Over 24 hours	0	1	1
Total	100	100	100

Since a large percentage of all fires are discovered by patrolmen or others who start to put them out immediately, the time from discovery to start of work should be short. It would be more important to know more about the time from the start of fires to their discovery. Full information about the time that elapses from origin to discovery would be valuable in determining whether patrolmen are able to discover fires as promptly as lookouts. However, no attempt was made to analyze discovery time because the reports do not indicate which times of origin were guessed and which were known.

Another important item, the time elapsing from the time work started on the fire until it was reported "under control" is analyzed in table 19. This indicates that all fires of $\frac{1}{4}$ acre or less were

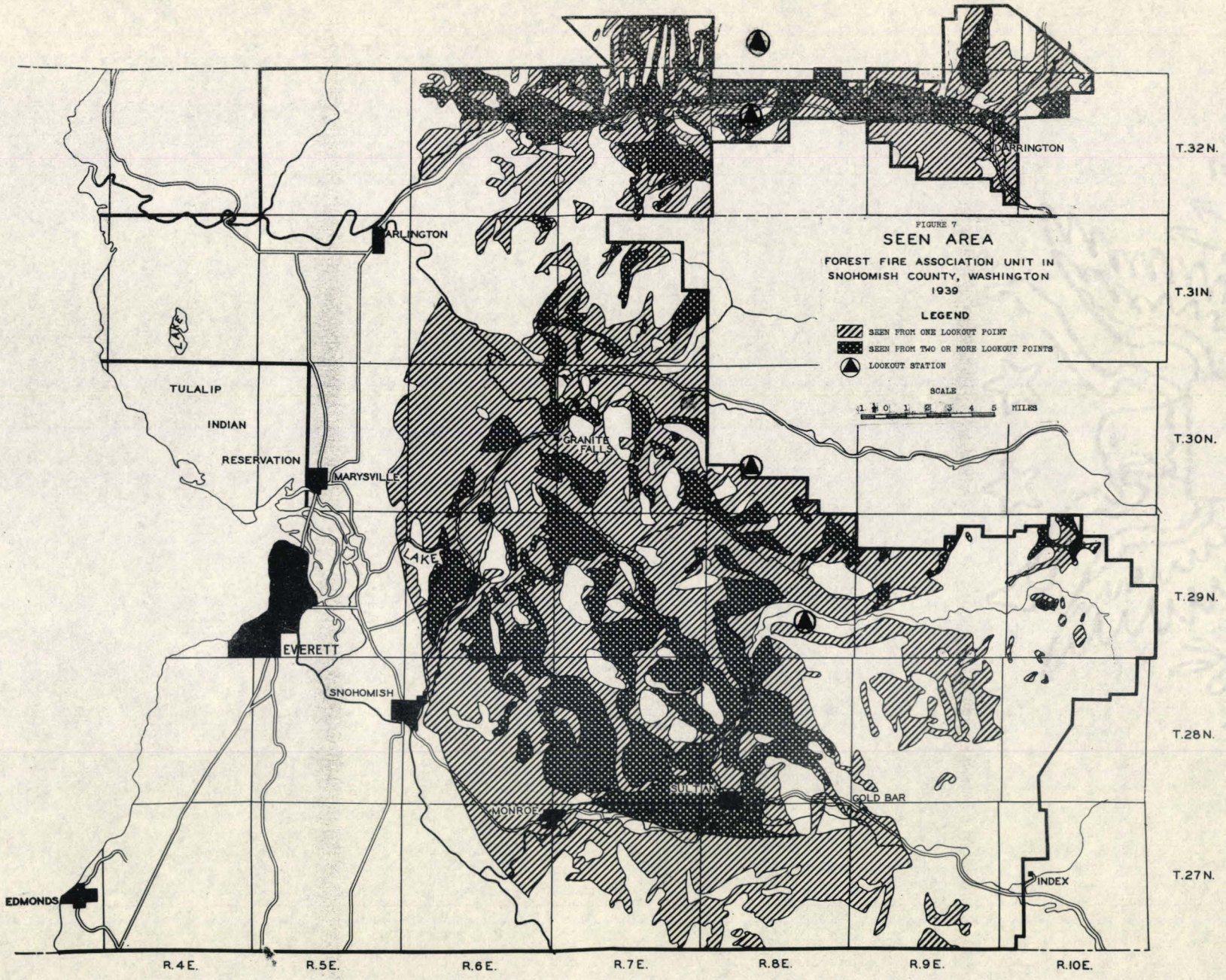


FIGURE 7
SEEN AREA
FOREST FIRE ASSOCIATION UNIT IN
SNOHOMISH COUNTY, WASHINGTON
1939
LEGEND
SEEN FROM ONE LOOKOUT POINT
SEEN FROM TWO OR MORE LOOKOUT POINTS
LOOKOUT STATION
SCALE
1 0 1 2 3 4 5 MILES
ARLINGTON
DARRINGTON
TULALIP
INDIAN
RESERVATION
MARYSVILLE
GRANITE FALLS
LAKE
EVERETT
SNOHOMISH
SULTAN
GOLD BAR
MONROE
INDEX
EDMONDS
T.32N.
T.31N.
T.30N.
T.29N.
T.28N.
T.27N.
R.4E.
R.5E.
R.6E.
R.7E.
R.8E.
R.9E.
R.10E.

under control within 6 hours or less; 88 percent of the fires of 1/4 to 10 acres were under control within 6 hours or less; 54 percent of all the fires over 10 acres were put under control in the same time, and only 15 percent of these larger fires or but 2 percent of all fires required more than 24 hours for control. Although the term "under control" does not mean that the fire was out, nevertheless these figures indicate that a high standard of suppression action was maintained in the unit.

Table 19.--Elapsed time from "work began" to fire "under control" by size of fire

Time	Size of fire when controlled			
	¼-acre or less	¼ to 10 acres	Over 10 acres	All sizes
	Percent	Percent	Percent	Percent
0-6 hours	100	88	54	90
6+ - 24 hours	0	11	31	8
Over 24 hours	0	1	15	2
Total	100	100	100	100

ANALYSIS OF COSTS AND FINANCIAL SUPPORT

Some consideration of the costs of fire control in the unit is necessary to complete the analysis of present protection and to serve as a reference point for the discussion of adequate protection which is to follow. It is customary to think of fire protection in terms of cost per acre, but it is wrong to appraise the adequacy of protection by the amount of money spent. Results and not expenditures are what count in fire control. Therefore, costs will not be used in this analysis to indicate the adequacy of the fire control that the unit is receiving. Finances in general are, however, one of the major problems of fire control, and this section will focus attention on three financial questions: (1) What does present protection cost? (2) How and where is the money spent? (3) Where does the money come from?

What Does Present Protection Cost?

The cost of fire control in the Snohomish County unit was found to be about $27,900 per year. This figure is based on the salary and other general overhead expenses for 1938 and the average annual fire fighting expense from 1935 to 1939 inclusive. It does not include the value of CCC improvements, which would amount to several thousand dollars additional. Spreading the $27,900 over the 546,030 acres of forest land protected, a cost of about 5 cents per acre is obtained.

The costs used include: Association expenditures for all purposes in the unit and a share of its central office overhead; State

expenditures (including Clarke-McNary money) in the unit and a share of State overhead; fire fighting costs of individual land owners; and the important but elusive item, the estimated value of CCC services in fire fighting, but nothing for the value of CCC improvements or other contributions. The CCC's were valued at 35 cents per man hour of fire fighting time without any additional allowance for subsistence, transportation, or overhead. Since 35 cents per hour is the going wage for fire fighters in the unit, use of this figure gives a rough approximation of the replacement value of the CCC fire fighters. Private expenditures for special watchmen, patrolmen, or equipment in logging camps or special railroad patrolmen are not included. This item would amount to several thousand dollars, but it is not customary to include it. These figures serve to indicate certain important features of the financial situation in this unit and probably also in other similar units.

How and Where is the Money Spent?

Table 20 indicates how the money is spent. The major item is field salaries and expenses, 68 percent of the total, which includes all the salary and expenses of all the field personnel on all activities including fire fighting and improvements. A considerable portion of the fire fighting is done by this regular force. Special expense for additional fire fighters accounts for 17 percent of the total cost of fire control. The estimated replacement value of the CCC's makes up a considerable part of this extra fire fighting cost. This item is broken down in table 21. Tools and equipment (hand tools, automobiles, trucks, tractors, pumps, hose, etc.) and improvements (roads, trails, telephone lines, buildings, etc.) account for 11 percent of the total in table 20. If the CCC's were not in the unit the improvement item would probably be increased considerably, but there did not appear to be any practicable way to include the CCC contribution to improvements. The estimated share of Association and State overhead that this unit bears makes up 4 percent of the total cost.

Table 20.--Distribution of fire control costs

Item	Amount	Percent of total
Field salaries and expenses	$18,842	68
Fire fighting costs, CCC, etc.	4,716	17
Tools, equipment and improvements	3,140	11
Overhead	1,200	4
Total	$27,898	100

Table 21.--Distribution of average annual fire fighting costs, 1935 to 1939, inclusive

Item	Amount	Percent of total
Association	$ 140	3
State (Clarke-McNary money)	75	1
CCC	2,819	60
Individual land owners	1,682	36
Total	$4,716	100

The distribution of average annual fire fighting costs 1935 to 1939, inclusive (table 20), over and above the fire fighting done by the regular force of field men is shown in table 21. The Association and the State together paid only about 4 percent of these costs. By far the major part (60 percent) is contributed by the CCC's and their contribution might be increased or decreased, depending upon how the value of CCC fire fighting was translated into dollars. Individual land owners did considerable fire fighting on their own account. Part of this is due to self-interest, which makes them want to protect their own property values, especially such things as felled and bucked timber, logging machinery, bridges, etc., as well as avoid the payment of damages on adjacent property; and part of this private fire fighting expense is incurred because the State law prescribes that private land owners must fight their own fires under certain conditions.

In order to show where the money was spent, an attempt was made to distribute the total cost of fire control in the unit (table 20) between the four land use districts. The results of this rough and approximate distribution of costs is shown in table 22. It indicates that the cut-over district absorbs 67 percent or two-thirds of the total cost and costs about 8 cents per acre. Its costs per acre are double those of any other district. The virgin forest is lowest with a cost of about 2 cents per acre. However, the cut-over and virgin forest districts are so intimately related that they might be combined for cost purposes. Combining them gives an average per-acre cost of about 6 cents and includes about 76 percent of the total cost.

Table 22.--Approximate cost of fire control on forest lands by land use districts

Item	Land use districts				
	Virgin forest	Cut-over	Rural residential	Agricultural	Entire unit
Cost per acre	2¢	8¢	3½¢	4¢	5¢
Percent of total cost	9%	67%	17%	7%	100%

Earlier in the analysis it was shown that the virgin forest and cut-over districts have about 65 percent of the forest land (table 1) and 70 percent of the burned acreage (table 2), which seems to agree with the fact that they account for about 76 percent of the total fire control cost. But they have only about 46 percent of the total number of fires. Therefore number of fires does not appear to be a good index of fire business as reflected in costs.

Where Does the Money Come From?

The sources of the money used to pay the fire control costs in the sample unit are shown in table 23. This table indicates that about 41 percent of the total cost was met by the forest land owners who belong to the Association and who pay at the rate of $2\frac{1}{2}$ to 4 cents per acre per year (1936, $2\frac{1}{2}$ cents; 1937, 3 cents; 1938, 3 cents; 1939, 4 cents; and 1940, $3\frac{1}{2}$ cents), and those land owners who pay the fire patrol assessment at the same rate. Since it may be noted that the Association and tax roll acreages in the Snohomish County unit multiplied by these rates yield sums that are less than the amount of Association and tax roll money expended in the unit it should be mentioned that collections and expenditures of these funds are not balanced on a county basis. Furthermore, there are additional Association and tax roll lands in Snohomish County inside the national forest protection boundary and not included in this report which are a source of money.

The total of State appropriations and Federal Clarke-McNary funds representing 43 percent of the fire control money is more significant than the share borne by each in this one sample because these funds are not balanced by units. In the State of Washington the Clarke-McNary funds exceed the State appropriations for fire control. The Clarke-McNary funds are appropriated to strengthen fire control on all classes of State and private forest lands. They are disbursed by the State and do not pass through the Association. They are used to pay wardens' salaries, buy tools and equipment, and pay fire fighting costs. The estimated value of the Federal contribution through CCC fire fighting activities amounts to about 10 percent of the total. If the value of the roads and other improvements constructed by the CCC were included the Federal contribution would be larger by several thousand dollars. Individuals fighting fires on their own lands or operations pay about 6 percent of the cost. They also make other fire control expenditures which are not on record and therefore could not be included. The Federal government does not make any direct payment for the protection of national forest land in this or other State or Association units in Washington because when one is balanced against the other on a State-wide basis the acreage of private and State lands protected by the Forest Service inside national forest protection boundaries exceeds the acreage of national forest land in outside units.

Table 23.--Source of money spent on fire control

Source	Amount	Percentage of total
Association and fire patrol assessments 1/	$11,513	41
State appropriations 2/ $8,412		
Federal - Clarke-McNary funds 2/ 3,472	11,884	43
Federal - CCC fire fighting only 3/	2,819	10
Private owners and operators 4/	1,682	6
Total	$27,898	100

1/ Based on expenditures in 1938.
2/ Based on expenditures in 1938. The proportion of the cost borne by each of these sources in this sample unit in one year is not significant because these funds are not balanced on a unit basis.
3/ Represents a conservative estimate of the average annual value of CCC fire fighting, 1935 to 1939, inclusive, based on 35 cents per man hour and does not include any estimate of the value of roads and other improvements contributed by the CCC, which would amount to several thousand dollars additional.
4/ Average annual expenditure for fire fighting, 1935 to 1939, inclusive.

Early in the analysis it was shown that 41 percent of the forest land in the unit is in the non-paying class (table 6). This forest land is not making any direct contribution towards paying its share of the costs of fire control, although it requires and receives fire control service and adds to the cost of fire control. Table 24 indicates the importance of the lack of income from these non-paying lands. The figures are based on a flat rate of 5 cents per acre on all lands to meet an annual cost of approximately $27,300. On this basis Association lands would pay 16 percent and tax roll lands 20 percent of the total cost or a total of 36 percent, while the 224,030 acres of non-paying lands (table 4) at the same rate should be contributing 41 percent of the cost. State lands would pay 18 percent and national forest lands would pay 5 percent of the total cost.

Table 24.--Distribution of total fire control costs if lands of each protection status paid at rate of 5 cents per acre

Protection status	Area	Amount each would pay	Percent of total
	Acres	Dollars	Percent
Association	87,180	4,359	16
Tax roll	107,650	5,383	20
State	101,240	5,062	18
National forest	25,930	1,297	5
Non-paying	224,030	11,202	41
Total	546,030	27,303	100

The important point is that 41 percent of the total forest land in the unit is not making any direct contribution to fire control, although it requires and receives fire protection. Therefore the financial burden is materially increased on the lands that are making a direct contribution.

The proportion of these non-paying lands varies greatly by land use districts. As shown in table 6, only 6 percent of the forest land in the virgin forest district is in this class. Although only 28 percent of the forest land in the cut-over district is non-paying it amounts to 65,800 acres because of the large total acreage of forest land in the district. Eighty-one percent and 78 percent of the forest land in the agricultural and rural residential districts, respectively, are not paying any part of the cost of fire control. A considerable part of the non-paying lands in all districts is tax delinquent or county owned.

BURNING RATES AND THEIR RELATION TO FOREST MANAGEMENT

Burning Rates

The annual burning rate is one measure of the adequacy of fire control. Control is adequate when it holds fire losses to a level which makes forest management practicable. The private owner cannot afford to invest in forestry when fire losses constitute a greater risk to his capital than the risks offered by other similar enterprises. Fire losses may mean the difference between profit and loss in private forestry. Public forest management is not so directly concerned with immediate money profits, but even in its case fire control is not adequate until it makes it possible for the public forest land to produce an uninterrupted flow of tangible and intangible benefits to the public.

Burning rates in the Snohomish County unit were analyzed to determine their relationship to forest management. Figure 4 indicates that about 3,000 acres burned over per year in the five-year period 1935 to 1939, inclusive. On the 546,000 acres of forest land in the unit this indicates a burning rate of about one-half of one percent per year. Usually one-quarter of one percent is considered the maximum allowable annual burning rate under which sustained yield forestry is feasible in the Douglas-fir region. Therefore the burning rate in Snohomish County appears to be too high, and it should be reduced. This is discussed further in the opening paragraphs of Part II of this report.

The over-all, average burning rate of one-half of one percent based on all fires and all forest cover conditions does not reveal any of the significant details about fire depletion. There are important differences in the burning rates in different cover types and in the same cover type in different locations. In order to reveal these differences table 25 was prepared, in which burning rates per 100,000 acres of forest land have been computed by cover types, land use districts, and protection status classes.

Table 25.--Burning rates per year by cover types, by land use districts and by protection status in units of percentage[1] of the given type, district, or status

By cover types

Period	Timber	Reproduction	Non-reforested	Unburned slash	All types
1935-1939[2]	0.005	0.21	0.91	16.20	0.50
1930-1934[3]	0.004	0.45	1.76	10.00	0.83

By land use districts, 1935-1939

Cover type	Virgin forest	Cut-over	Rural residential	Agricultural	All districts
Reproduction	0.62	0.14	0.24	0.36	0.21
Non-reforested	0.00	0.96	0.82	0.86	0.91
All types[4]	0.007	0.76	0.47	0.48	0.50

By protection status, 1935-1939

Cover type	Association	Tax roll	State	National forest	Non-paying	All classes
Reproduction	0.48	0.14	0.25	0.03	0.19	0.21
Non-reforested	1.20	1.06	0.46	0.05	0.78	0.91
All types[4]	0.53	1.05	0.18	0.02	0.42	0.50

1/ 1.000 = 1 percent = 1,000 acres per year per 100,000 acres.
2/ Computed on 1938 area of each type.
3/ Computed on an estimated 1932 area of each type.
4/ Includes timber, reproduction, non-reforested, and unburned slash.

The outstanding feature revealed by table 25 is that unburned slash has a burning rate of a much greater magnitude than any other cover type. The rate is so high that it indicates that there is scant possibility of successfully carrying unburned slash through a reforestation period under the present level of protection. The actual acreage of slash varies from year to year, and the rate computed on the 1939 acreage is not precise, but it is undoubtedly correct to the extent of indicating that the burning rate in this cover type greatly exceeds that in any other. It is also significant that timber has a very low burning rate of only a few hundredths of one percent per year. Thus

the timber types, which have the highest present per-acre value, appear to suffer less from fire than any other type. Timber losses were so small that they were omitted from the tables of burning rates by land use districts and protection status in table 25. The burning rate in the non-reforested cut-over type of 0.96 is high, although not so high as has been found in larger samples of the Douglas-fir region where burning rates of 3 or 4 percent per year have been found in this type.

The burning rates in the various land use districts reveal that forest land in the agricultural and rural residential districts fares well as compared to forest land in the cut-over district. Reproduction has a low burning rate in all the districts where most of it occurs, but the burning rate on non-reforested lands is high in all districts. Considering all types the cut-over district's rate of 0.76 is the highest. The burning rate in the virgin forest district is much lower than in any other district and is correlated with the occurrence of timber as the principal cover type.

Perhaps the most interesting comparison in that part of table 25 which shows burning rates by the protection status classes is that between the rates on non-paying lands and the rates on Association and tax roll lands. Apparently non-paying lands have about the same or a lower burning rate than paying lands, and from this it may be deducted that they receive about the same level of protection as the paying lands with which they are intermingled.

Relation Between Fire, Growth, and Depletion

The cutting depletion rates and growth rates obtained by comparing the Forest Survey inventories and reports of 1932 and 1938 can be combined with the burning rates obtained in the present study to give a broad picture of the state of forestry in the unit. In 1938 there were 146,000 acres of timber, 232,000 acres of reproduction and 168,000 acres of non-reforested lands (including unburned slash) in the unit (table 7). Past cutting rates revealed by comparing the Forest Survey inventories indicate that 40,000 acres of the timber may be cut over between 1938 and 1948, adding that many acres to the non-reforested lands of that date. It is estimated that during this decade 10,000 acres of what is classed as reproduction in this report may be cut over, adding 10,000 acres more to the non-reforested lands of 1948. Past burning rates indicate that about 7,000 acres of the 1938 acreage of reproduction will burn over and be classed as non-reforested by 1948. The Forest Survey inventories indicate that in spite of fire at present rates and owing to natural restocking about 65,000 acres of the 1938 acreage of non-reforested land will pass into the reproduction type by 1948. As a result of these changes there should be 106,000 acres of timber, 280,000 acres of reproduction and 160,000 acres of non-reforested land in the unit in 1948 as shown by the following summary:

	1938 (Acres)		1948 (Acres)
Timber	146,000 - 40,000 =		106,000
Reproduction	232,000 - 10,000 - 7,000 + 65,000 =		280,000
Non-reforested	168,000 - 65,000 + 40,000 + 10,000 + 7,000 =		160,000
Total	546,000		546,000

Carrying the same hypothetical figures through another decade beyond 1948, with the exception that the cutting depletion in the timber is reduced to 30,000 acres and increased in the reproduction to 20,000 acres a similar balance can be cast as follows:

	1948 (Acres)		1958 (Acres)
Timber	106,000 - 30,000 =		76,000
Reproduction	280,000 - 20,000 - 7,000 + 65,000 =		318,000
Non-reforested	160,000 - 65,000 + 30,000 + 20,000 + 7,000 =		152,000
Total	546,000		546,000

One of the significant features of these figures is the small reduction in the large present acreage of non-reforested lands even at the end of two decades. The presence of over 150,000 acres of non-reforested potentially productive land looms large in the broad picture of forestry in the unit. If the hypothetical figures make a true forecast of the future, continuance of the present rate of cutting and present management practices, including the present level of fire control, supplemented by natural reforestation, will pereptuate a large acreage of non-reforested and unproductive forest land.

It is also indicated that even complete exclusion of fire from the present time forward would not greatly decrease the amount of non-reforested land at the end of two decades. Therefore adequate fire control alone starting now cannot solve one of the major forest management problems of the unit; i.e., conversion of the large acreage of non-reforested land into forested land. Considering the non-reforested lands it seems probable that past fire history, and particularly the fires of 15 to 25 years ago (figures 3 and 4) when the burning rates were much higher than in recent years, may have been responsible for creating conditions which even adequate fire control from this time forward cannot cure. Artificial reforestation may be necessary. When applied throughout the life of the forest adequate fire control may be the first requirement of forest management in the Douglas-fir region, but important as it is it cannot cure conditions brought about by past abuses.

Part II
SPECIFICATIONS AND COSTS OF ADEQUATE FIRE CONTROL IN THE SNOHOMISH COUNTY UNIT

In order to develop specifications of adequate fire control and make suggestions for their application to the sample unit, it is necessary, first, to decide to what fire control should be applied, and second, to define adequate fire control.

TO WHAT SHOULD FIRE CONTROL BE APPLIED?

In a civilized community all values that are susceptible to damage by fire must be protected from fire. Applying this very broad viewpoint to the sample area leads to the conclusion that all grass, weeds, brush, forests, buildings, and other inflammable properties in all parts of the unit require fire control. Properties in cities and towns can be eliminated from consideration here because they have their own special fire protection. The cover on cultivated lands and improved pastures and the buildings thereon merit consideration to the extent that they are inflammable, but they are not the special concern of this report. There remain all the forest lands and their inflammable improvements. How are they to receive fire control service? Do they fall within the province of forest fire control? These are questions that must be answered before adequate fire control can be defined and specifications developed.

Before making a direct answer to these questions it may be desirable to make a distinction between managed and unmanaged forest land, which in all previous discussions have been included in the term "forest land." At the present time they may both have the same physical appearance, but the unmanaged land is not valued, dedicated, or used for forestry purposes. In sharp contrast to this, managed forest lands are valued, dedicated, and used for forestry purposes. Positive ownership as evidenced by the payment of taxes and fire control costs is the minimum evidence of a managed forest. In addition, the owner should have an active intent to use the land for the production of forest values. Negative ownership as exemplified by tax delinquency, failure to pay fire control costs, and lack of intent to create forest values is evidence of an unmanaged forest. On the basis of this definition most of the cut-over land, restocking and nonrestocking, in the Snohomish unit is unmanaged forest land. Also, most of the 224,000 acres of non-paying forest lands is evidently unmanaged, with the possible exception of some of the areas having residence exemption. Even if it is conceded that holding and protecting old-growth or second-growth timber for future liquidation makes the land involved managed forest land, that all State and Federal lands are managed forest lands, and that a few private owners are actively managing their cut-over land for forestry, the total of such managed land in the sample unit comprises but a fraction of the total area after eliminating cities, towns, cultivated land, and improved pastures.

It is not feasible to limit fire control to managed forest lands as here defined. The distinction between unmanaged and managed forest land is made on the basis of management or use. It is not based on cover conditions or inflammability. Unmanaged forest land may be just as inflammable as managed forest land; in fact, it tends to be even more so. Therefore, where the two kinds of forest land are intermingled fire control must be applied to both because fires occurring on the unmanaged will jeopardize the managed forest land. It is absolutely impracticable to apply fire control to a managed forest property and do nothing on adjacent unmanaged land. This concept is basic to the development of adequate forest fire laws and fire control practices. It may be good practice to give managed lands extra protection, but all lands in large natural blocks must have some protection before any can be considered as being satisfactorily protected.

By this time it should be clearly indicated that all the unmanaged and managed forest land in the virgin forest and cut-over districts should receive fire protection. Going a step further, it can be stated that they should all receive the level of fire control required as a minimum on the managed forest land, partly because it is impracticable to discriminate in the application of fire control and partly because it is good long-time public policy to assume that most of the unmanaged forest lands in these districts will eventually come under management. Therefore it is in the public interest to lay the foundation for their management by giving them protection from fire. This means that all lands in these districts should receive adequate forest fire control as it is to be defined and developed in subsequent sections of this report, and it should be administered by the forest fire control agency.

The facts brought out by the analysis and the present discussion also clearly indicate that the managed and unmanaged forest lands in the agricultural and rural residential districts require fire control. But it may not be clear what kind of fire control they should receive or by whom it should be administered. Managed forest lands are a minor element in these districts at present, and it is not certain that the unmanaged lands will eventually come under management for forestry purposes. The need for fire protection for buildings and other inflammable properties on the land assumes an important place. Nevertheless, 37 percent of the area of the agricultural district and 90 percent of the area of the rural residential district is forest land, either managed or unmanaged. In either case it has an inflammable cover and fires cannot be allowed to run uncontrolled because they would be a menace to life and property. Even in these districts both classes of land require an essentially forest type of fire control, and in addition an acceptable level of fire control should be provided for the buildings and improvements on a year-long basis.

Because of the minor amount of managed forest land, the large amount that may never become managed forest land, and the important place of building and other improvements, fire control in these districts is not automatically placed in the province of a forest fire control agency.

There is apparently no basic reason why it could not be so handled, but the important fact is that it could be handled in other ways. If there is going to be a forest fire control agency it would most certainly operate in the cut-over and virgin forest districts because they are or will be predominantly managed forest districts. But the other districts are not so predominantly forest districts, and a decision may be made whether to put them under the jurisdiction of the forest fire control agency or provide a separate agency to give them the particular kind of fire control service which they need.

It appears that the communities, the county, the State, or a fire control association such as the Washington Forest Fire Association could render the required service in the agricultural and rural residential districts. If a separate organization were provided a certain amount of State-wide coordination would be desirable, especially to guide and make effective prevention, regulatory, and law-enforcement activities. Finances might be a controlling factor because the protection afforded should be universal and it should, in turn, be financially supported by all properties. Taxes, rather than voluntary assessments, are indicated. One of the most important services government can give to managed or unmanaged forest land and its improvements is fire protection; hence some considerable part of the taxes paid by such properties could be properly devoted to this purpose. Schools and roads have their place, but protection of property from loss by fire is a basic function of government that should be supported by the taxes levied to support the government. But this report is more concerned with the principle that all forest lands and associated properties needing fire control should receive it than with making specific recommendations about the type of administration required.

In the remainder of this report it will be assumed in developing the specifications of adequate fire control and in discussing finances that one fire control agency will give service to all forest lands of all four districts in the unit. Since it might develop that part of the rural residential and agricultural districts could be more satisfactorily served by a separate fire control organization the above assumption should not be taken as a recommendation or as an indication that this is considered to be the best or only way to administer fire control in the unit.

WHAT IS ADEQUATE FIRE CONTROL?

Definition

Forest fires cannot be regulated to do just so much damage and no more. They cannot be turned off at will. To tolerate any fire whatsoever is inviting disaster. The only safe practice is to make the number of fires and fire losses approach zero. Ideal fire control would be attained by the complete elimination of all fires but, being restricted by financial considerations, that is not a practicable objective and something less than the ideal must be accepted as adequate. The term "adequate" itself implies a compromise; adequate fire

control is not absolute or ideal or perfect fire control, but it is an attainable level of fire control somewhere between perfect control and no control which will maintain the forest values on public or private forest lands with due regard to economic considerations, such as the balance between costs and losses.

Determination of the level of fire control which can be accepted as adequate is essentially a problem in economics. Forest fires menace human life and destroy some intangible values not ordinarily converted into dollars, but the statement is still true that economics will governn in setting up the objective and specifications of adequate fire control. It is for this reason that the economic objective or theory of fire control has been developed and used by fire control planners for many years. It is based on the viewpoint that expenditures for prevention, presuppression, and suppression should be in balance, and together they should be balanced against damage. Fire control costs and fire damage are both considered to be a charge against forest profits. If the amount spent on prevention is too low, the cost of presuppression and suppression will mount; if the amount spent on all fire control measures is too low damage will be high; and if too much is spent on fire control the damage may be reduced at too great an expense. The ideal is to keep prevention, presuppression, and suppression expenditures in balance with damage so that the net result will represent the lowest total cost to forestry. Ideal and useful as this objective may be, there are several difficulties that stand in the way of its practical application. For one thing, the dollar value of fire damage is almost an unknown quantity. Also, lacking precise measurements of the relative results obtained from a dollar spent for prevention or presuppression or suppression, the point of balance between these items and damage--another unknown--cannot be computed in advance but must be determined by experience.

Because of these very real difficulties encountered in applying the economic objective to specific areas the burned-area objective has been developed by foresters as a substitute. An acceptable objective for the Douglas-fir region is to limit the average annual burning rate to one-quarter of one percent. (The Copeland Report, page 1399, gives 0.2 to 0.3 of one percent as the annual allowable burn in the Douglas-fir type.) This is considered to be the maximum burning rate permissible on managed forest lands if they are to be economically profitable. For want of any better measure and because it is good public policy to give them a degree of protection which will preserve their forest value, this same objective will be applied to the unmanaged forest lands of the unit.

Expressed in acres, this would indicate that about 1,200 acres could be burned over per year in Snohomish County. Actually, it is not nearly so simple as that. It would make a tremendous difference what cover types burned over, whether mature timber, second growth, seedlings, or recent cutovers, and the amount of reburn. Also, this rate is intended to represent an average burning rate over the entire Douglas-fir region, and a long period of time. Therefore it must

absorb all the region's large fires and catastrophes, good years and bad years, high hazard and low hazard areas. If the region's large fires and catastrophes continue to occur about as they have in the past, they will make up a major part of the one-quarter of one percent even when they are spread over the entire region and several decades. For example, the 245,000-acre Tillamook fire of 1933 consumed several years of the entire region's allowable burn.

Although, all things considered, the only safe procedure in setting up an allowable burn objective for any one unit within the Douglas-fir region is to specify that ordinary fire losses shall be reduced to as near zero as practicable, nevertheless, in order to be specific a maximum annual burning rate of one-quarter of one percent is set up as the objective for adequate fire control in the Snohomish County unit. Even so, the term "adequate fire control" describes an elusive quantity and quality that cannot be reduced to engineering exactness like the specifications for a bridge or a tower; nevertheless, experience has established certain specifications that can be used to attain satisfactory results. The degree of protection afforded will depend upon the intensity of the application of each of these specifications and the balance maintained by keeping them abreast of each other. The next step will be to state these specifications, and subsequent sections will discuss each in detail.

SPECIFICATIONS OF ADEQUATE FIRE CONTROL

Summary of Specifications

Adequate fire control can be obtained by the strict application of the following specifications to all managed and unmanaged forest lands:

1. Make constant effort to reduce the number of man-caused fires.

2. Exercise control over special hazards such as slash and over the use of fire during all possibly dangerous fire weather.

3. Obtain prompt discovery and report of all fires during all possibly dangerous fire weather.

4. Take immediate suppression action on every fire as soon as it is physically possible to put one or more men to work on it.

5. Make a thorough, sustained effort to stop the spread of all fires as rapidly as possible and to do such additional work as will insure that they will not spread again.

6. Make a constant effort to improve the efficiency and effectiveness of all fire control activities.

7. Provide strong, flexible financial support.

These specifications of adequate fire control offer a practical base upon which to build a fire control plan for the sample unit. They call for a high level of fire control performance, but at the same time are sufficiently flexible to cope with actual conditions. In describing a plan of action to put these specifications into effect, the aim will be to develop or suggest processes and principles rather than details of action. Details will be used as examples. Costs of putting the plan into effect will be discussed briefly near the end of the report.

The specifications and the specific suggestions for their application to the Snohomish County unit are not limited to what can be done under existing forest fire laws of the State of Washington. This is a statement of what should be done to obtain adequate protection. If new legislation is necessary to meet these requirements, that is a separate and distinct problem. The statement that a certain action should be taken does not necessarily mean that it is not being taken. Much that is recommended is already being applied and is included for completeness.

1. MAKE CONSTANT EFFORT TO REDUCE THE NUMBER OF MAN-CAUSED FIRES

Suggested General Plan of Action

1. Enforce the forest fire laws.

2. Study each fire to determine why it occurred and how it might have been prevented. Make a full and complete report on each man-caused fire and look upon every fire as a problem to be solved. Determine occurrence zones, general causes, specific causes, classes and sources of people responsible, and motives and reasons as the basis for solving the problem through education, closures, and law enforcement.

3. Conduct a constant education campaign. Use the personal contacts of all the fire control personnel in the unit to prevent fires. Make fire prevention a major activity of each employee. Conduct special fire prevention contests in the schools of the county. Work with the 4-H clubs and county agents. Contact each school (about 50 in the county), grange, church, club, or other organization at least once each year. There are about 15 cities, towns, or larger communities. Make full use of local newspapers and radio broadcasts. Maintain close personal contact with loggers, miners, sawmill operators, and all industrial forest users. Encourage local cooperators to do educational work in fire prevention. Maintain active cooperative relationships with State and national forest fire prevention campaigns.

4. Use each of the thousand or more permits issued annually as an opportunity to instruct the public in fire prevention. Take follow-up action on each permit and make full use of its prevention value.

5. Determine the damage done by fire to the forest lands of the county and educate people by demonstrations, show-me trips, talks, etc. Get the facts and train all the personnel of the unit to speak with authority about forest values and fire damage.

Discussion of Fire Prevention by Land Use Districts

Virgin Forest. Except for a few miners no one lives in this district. There are only about 16 miles of roads. Recreational use is light. The most serious threat comes from the danger of fire running in from the outside, especially from the cut-over lands and the logging operations that are working their way into this district at several points. Several thousand acres of the virgin forest district will pass into the cut-over classification each year. Lightning is the most important single cause of fire in this district, and it is not preventable.

The following specific prevention measures are suggested as being applicable to this district:

(a) Enforcement of State laws.

(b) Prompt disposal of slash or special precautions to prevent fires therein.

(c) Contact recreationists using the area. Campfire permits should be helpful. Encourage public to contact wardens before entering this area. Cooperate with adjacent national forest officers.

(d) Contact miners. Exercise control over their creation of special hazards such as slash and over their debris burning.

Also, the fire prevention measures applied to adjacent lands in the cut-over district will be extremely important to this district.

Cut-over. This district contains all of the large logging operations in the unit. It also contains a well scattered and varied assortment of smaller woods operations including sawmills and shingle mills and pulpwood, fuelwood, and shingle-bolt operations. These large and small industrial operations and their camps are a major feature of the fire prevention problem of this district.

There are a few farms scattered within the district, but practically no grazing except in fenced pastures. There is also a considerable number of small tracts or lots used for residential purposes. A small amount of land clearing is going on all the time. This district contains several attractive lakes and streams and there is considerable fishing, hunting, camping, picnicking, and other recreational use. Berrypicking takes large numbers of persons out into the cut-over lands during fire weather. A major trans-State highway and several lesser highways and numerous roads make this district accessible to the public. One transcontinental railroad crosses it.

Suggestions for specific prevention measures for this district:

(a) Enforce State laws.

(b) Periodically inspect all large and small woods operations and enforce State laws governing the same. Daily inspections should be made during periods of maximum fire danger. Obtain telephone service to all larger operators.

(c) Keep posted on fire danger in all parts of the district by maintaining fire danger stations and following fire weather forecasts. Encourage all larger operators to do the same. Wardens should have the best possible information about fire danger conditions so as to properly administer shut-downs, closures, and the issuance of burning permits.

(d) Exercise full control over the creation and abatement of hazards. Slash hazards should be reduced promptly or special precautions taken to prevent fires from starting in them.

(e) Maintain close cooperative arrangements with all forest land owners and woods operations for the prevention of fires.

(f) Contact recreationists while they are in the district. Make daily visit to camping or parking spots. Take special precautions to prevent berry pickers' fires.

(g) Provide service to the public so they will be encouraged to consult with wardens before going into remote parts of the district. Keep posted on roads, trails, fishing, hunting, and berries and pass this information along.

(h) Encourage the development of State, county, municipal, community, or private parks, camps, picnic grounds, and other recreational centers. All such recreational developments should be properly maintained and supervised by their sponsors. Discourage the use of undeveloped and unsupervised sites for recreational purposes, especially in areas of high hazard.

(i) Help residents to burn their land-clearing debris. Encourage them to clean up debris next to roads, camping or parking spots and fishing streams or lakes.

(j) Help land owners to prevent trespass.

(k) Take special measures to prevent incendiary fires.

(l) Where gates or other closures are used make them effective and free from exceptions.

(m) Make forestry the major land use in this district. Prevent settlers from attempting to develop farms in remote parts of the district. Consolidate and dedicate State and county lands for forestry purposes and prevent their sale for uses incompatible with forestry.

Rural Residential. This district's fire prevention problems are chiefly colored by its dense population on small tracts or lots intimately associated with forest cover. These residents are not supported by

the land on which they live. Most of them work in near-by cities, mills, logging camps, etc. This district contains a few self-sustaining farms. It contains recreational developments along the shores of Puget Sound and several lakes. It is crisscrossed by a network of highways, roads, railroads, and power lines. At least 75 percent of the area of the district is within one-fourth mile of a road of some kind. Flashy fuels such as bracken and weeds abound on large areas. There is some small-scale logging, pulpwood and fuelwood cutting, and in the aggregate a considerable amount of land clearing going on all the time. About 59 percent of the burning permits issued in the protection unit are obtained by residents of this district.

Suggestions for specific fire prevention measures:

(a) Enforce State laws.

(b) Contact every family living near essentially forest cover at least once each fire season to talk fire prevention, point out dangerous details of construction, dangerous accumulations of fuels, help them do their debris burning at safe times and advise them about fire suppression equipment that they should keep on hand; explain procedure for obtaining burning permits and their purposes. Also, to get cooperation in prompt reporting of all fires explain how to report a fire.

(c) Maintain a fire danger rating service.

(d) Encourage residents to clean up dangerous accumulations of fuels.

(e) Make field inspection follow-up of all burning permits issued.

(f) Educate children in the schools in forest fire prevention.

(g) Help owners to prevent trespass.

Agricultural. As its name implies, this district is characterized by farms. Only 37 percent of the total area can be classed as forest land and much of this is a part of the farms. It contains a few areas of isolated forest land of a thousand acres or more that might be shown as islands of non-agricultural cutover in a more detailed classification. This district contains a large part of the total mileage of major highways, mainline and branch railroads, and the principal rivers of the unit. There are small land clearing operations going on all the time throughout the district.

About 50 percent of the fires in this district are caused by smokers and these appear to be closely associated with roads. Brush burning and miscellaneous fires account for most of the remainder.

The value of the products of farm woods when harvested during slack seasons and sold for logs, poles, pulpwood, and fuelwood should not be overlooked as an opening wedge to forest fire prevention in this district. There is an opportunity here for an extension forester to help the farmers obtain more income from their forest lands and at the same time gain their support for forest fire prevention. The Washington Forest Products Cooperative Association, the first forest products cooperative west of the Mississippi River, was formed in Snohomish County in 1940 and should be an important factor in this district.

The residents of this and the adjacent rural residential district are undoubtedly an important part of the fishermen, hunters, berry pickers, etc. in the other districts; therefore they make up an important group to reach with general fire prevention propaganda.

Specific fire prevention measures applicable to the agricultural district:

(a) Enforce State laws.

(b) Contact each family living near forest land at least once each year to talk about forest fire prevention, hazard reduction, burning permits, and cooperation in reporting fires.

(c) Give service to farmers that will help them to realize highest returns from their woodlands. Promotion of forest values is good basic fire prevention.

(d) Maintain such fire danger rating service as will aid in handling burning permits and other fire control activities.

(e) Make field inspection of burning permits.

(f) Educate children in the schools in forest fire prevention. Talk fire prevention at granges and community gatherings.

(g) Get the facts about fire damage to farm woods and spread this information by talks and demonstrations.

(h) Educate land owners to do their cutting in the manner and at the time that will create the least hazard.

(i) Help owners to prevent trespass on forest lands.

2. EXERCISE CONTROL OVER SPECIAL HAZARDS SUCH AS SLASH AND OVER THE USE OF FIRE DURING ALL POSSIBLY DANGEROUS FIRE WEATHER

Full control of the creation and abatement of special hazards of all kinds during all possibly dangerous fire weather is a basic requirement of adequate fire control. In this unit as in the Douglas-fir region generally, all woods operations such as logging, wood cutting,

land clearing, and right-of-way clearing make a very marked increase in total danger of fires starting and spreading because all these operations tend to increase the amount of fuel and to make it highly inflammable by exposure to the drying action of the sun and wind. (Kind, quantity, and condition of fuels affect the danger of fires starting. Experiments indicate that these factors determine the number of fires which will start from any given number of fire brands. For example, a discarded cigarette is more likely to start a fire in fully exposed slash than if dropped on the mossy forest floor under full shade.) The increase in fire danger due to these added fuels persists for 10 or 20 or more years, adds to the costs of fire protection, and increases the probability of losses from uncontrollable fires unless they are reduced or eliminated. Because these increased hazards may jeopardize private and public values beyond the limits of the property on which they are created the public has a right to regulate their creation and abatement.

Specific measures applicable to problems of special hazards and their abatement:

(a) Control over the creation of the hazard. The fire control agency should have control over the creation of special hazards and their abatement. Therefore anyone intending to perform any operation on forest land which will affect the fire hazard should be required to obtain permission and meet certain requirements before creating the special hazard. This is stated as a principle; there is no intent to prescribe the form such permission should take. It should describe the location, nature, and extent of the operation and fix responsibility for the creation of the increased hazard and for its abatement. It should include a plan for the abatement of the hazard; or, if it is better to leave the hazard unabated, the plan should provide for whatever special fire control measures should be applied. The financial responsibility of the operator should be established, and where necessary to protect the fire control agency a deposit or bond covering the estimated cost of the hazard reduction or special protection should be required.

(b) Special protection for special hazards. Ordinary fire control measures are aimed to cope with the average level of fuel hazard and fire occurrence. Where either one of these is more dangerous than usual special measures are necessary to obtain adequate protection. Thus the current slash on a logging operation requires special measures that are covered in the State laws and in the rules of forest practice in the Forest Practice Handbook. But all areas of higher than average fuels or fire occurrence also need a higher level of fire control effort. Where it is impracticable to burn slash, as after partial cutting, extra protection may be needed over a long period of years. Whether this can best be accomplished by adding patrols, making closures, or taking other measures must be decided for each specific area, but it should be recognized as a basic principle of adequate fire control that areas of more than average fire hazard should receive more than the average level of fire control measures.

The following are examples of areas of more than average hazard that deserve additional protection:

Cut-over lands south and east of Lake Roesiger.
Sections 4, 5, 9, 10, T. 27 N., R. 6 E.
Recent and current logging in NE¼ T. 28 N., R. 8 E.
Slash from partial cutting near highway in T. 27 N., R. 9 E.

(c) Control over use of fire. Adequate fire control demands that the protection agency have control over the use of fire for debris burning, land clearing, or hazard reduction during all possibly dangerous fire weather. The present practice of requiring burning permits is in the right direction. However, control of the use of fire implies much more than issuing a permit. Full compliance with this requirement of adequate protection would require that permits will be issued only for periods when it is safe to burn, for fires in safe places, and that fires will be put out promptly when conditions change. Full control over the use of fire will require field inspection of areas before permits are issued. This will aid the permittees to do their burning safely and will safeguard the public interest. Follow-up inspections will also be necessary.

The development of strict control of the use of fire should not deprive the logger, farmer, suburbanite, or others of their use of fire for useful purposes. Rather, it should control and direct this use so that it will accomplish its desired purpose without becoming a fire control liability. The wardens should be expert in the use of fire and able to give assistance to permittees.

(d) Recognition of "all possibly dangerous fire weather." The phrase "possibly dangerous fire weather" occurs several times in these specifications of adequate fire control. One explanation will serve to indicate what this phrase means wherever it is used.

As the phrase indicates, there are weather conditions under which fires will start and spread and other conditions under which they will not start or spread. The intent is to draw a line between these two conditions well on the safe side; hence the use of the word "possibly." It means that the combination of all weather conditions past, present, and future make fire dangerous in forest fuels. A day in August with a light shower may seem safe enough at the time of the shower, but because of the effect of many previous dry days and the probability of more dry days to come the day, light shower and all, would be classed as "possibly dangerous fire weather."

Adequate fire control demands that all days of possibly dangerous fire weather be recognized. Therefore the question of what is dangerous weather and how to measure and recognize it becomes extremely important. The fire weather service of the Weather Bureau helps to solve this problem. This service is particularly helpful in forecasting future weather conditions and in compiling records of past and present conditions. The

fire danger rating system developed by the Pacific Northwest Forest and Range Experiment Station and the administrative branch of the Forest Service in Washington and Oregon has proved to be useful in measuring and recognizing fire danger. To apply this system to this unit fire danger stations should be established in all parts of the area to measure fuel moisture content by means of the fuel moisture indicator sticks and wind velocity. Suggested locations would be Darrington (Forest Service station already in operation), Arlington, Granite Falls, Lake Roesiger, Sultan Basin, Snohomish County airport, Blue Mountain Lookout, and Sultan. The daily measurements obtained at these stations would be used by near-by wardens and also telephoned to Sultan and posted there for the information of the Chief Warden. The fuel moisture and wind measurements could be combined by means of the burning-index table to get an expression of burning conditions on a scale of 0 to 100. Constant checks of these ratings of burning conditions against local fire experience and local knowledge would soon develop a definition of possibly dangerous fire weather based on actual measurements and local fuel conditions. These measurements could be used to determine the necessity for extra patrols or lookouts, closures, cancellation of burning permits, shut-down of logging, etc.

Relative humidity can be used as another indicator of fire weather, although it is much safer to use also wind velocity and the combined effect of all factors upon the moisture content of the fuels. The essential item is to recognize all possibly dangerous fire weather and to act accordingly.

3. OBTAIN PROMPT DISCOVERY AND REPORT OF ALL FIRES DURING ALL POSSIBLY DANGEROUS FIRE WEATHER

Lookout Detection

The areas visible to established lookouts of the fire protection association and the Mt. Baker and Snoqualmie National Forest were mapped to determine what parts of the county unit are covered by lookout detection, using a 15-mile radius as the limit of coverage. It is found that a large area in the southeast corner of the unit, including much of the State exchange area, is invisible to lookouts. A smaller area along the east side of the county unit in the northern part and the western one-third of the unit is invisible. The remaining parts are almost completely covered by lookouts. Other likely lookout points that would cover the blind areas were studied from topographic maps and seen-area maps were drawn for those which would give considerable additional coverage.

The blind area in Tps. 31 and 32 N., Rs. 6 and 7 E. can be largely covered from a point near Twin Lakes (in T. 31 N., R. 6 E., sec. 12) and at the same time a large amount of blind area in the agricultural and suburban districts to the west will be covered. This point is in the vicinity of two current logging operations and covers a high hazard area. It is recommended that it be developed and be manned as an

emergency point whenever the burning conditions are critical. The point is near a logging road and is readily accessible. Some cutting of timber may be necessary to develop the point if the current logging has not already done that.

The blind area in the southeast corner of the unit cannot be covered except by adding several points having limited visibility. Part of this blind area is penetrated by roads and is subject to the use and man-caused fires from local residents and nonresidents. It is recommended that the point near Austin Creek (T. 27 N., R. 9 E., sec. 13) and the point near Wallace Lake (T. 28 N., R. 9 E., sec. 20) be developed for emergency use and that a patrolman visit both points twice during the afternoon on days of dangerous fire weather. The areas covered by these points include brush, reproduction, and slash and present a moderately high hazard.

The blind area in the State exchange area along the upper Sultan River is important in case of a severe lightning storm. This area is covered with low hazard timber and is not subject to much public use at present. From the point south of Iowa Cabin (T. 29 N., R. 10 E., sec. 20) it may be possible to see most of the Sultan River Valley that is blind to established lookouts. If it proves practicable to reach the point by trail from the Sultan River road and to develop it with a shelter and fire-finder base, a man should be sent to the point for several days following lightning storms over the Sultan basin.

In the southwestern part of the county beyond the range of the established Snohomish County lookouts the fire occurrence is greatest, and the topography is so flat or rolling that it is unfavorable for lookout detection. It is thought some of the area may be visible to lookouts in other units, and a field check should be made to determine the extent of such visibility. The area is relatively thickly populated and is gridironed by roads. The cover is a mixture of nonrestocking brushland, reproduction, and small patches of large second-growth timber. Several locations appear favorable for patrolmen to visit for inspecting areas two or three miles in extent. One is west of Cathcart about two miles in T. 27 N., R. 5 E., sec. 11. Another is west of Maltby three miles in T. 27 N., R. 5 E., sec. 21. A third is along the Pacific Highway in T. 27 N., R. 4 E., sec. 3. These locations should be further examined in the field to determine if the topography and forest cover will allow a lookout on a tower to see sufficient areas beyond the limit of direct visibility to justify the expense of building and manning one or more towers.

This part of the county is not as great a problem in fire detection as most forest areas invisible to lookouts and having heavy use. Here there is a large number of rural residents who are interested in protecting their buildings and land from fires on surrounding forest land and as indicated by the individual fire reports they usually discover fires quickly. If the residents are enlisted and well instructed in reporting fires to the local warden acceptably prompt action on all

fires should be obtained.

The territory north of Everett that is invisible to lookouts is largely agricultural land not requiring intensive fire detection, and the forest land occurs principally in three widely scattered areas too small to warrant a separate lookout. This territory, like that south of Everett, is thickly populated and gridironed by roads. Fire detection and reporting by patrolmen and local residents should be acceptably prompt if the public is properly trained in reporting the fires.

The established lookout system of the State and the Forest Service gives adequate coverage over a large part of the Snohomish County unit during July and August, but the Forest Service protective area is not subject to fires as early in the spring as the outside unit and the Forest Service lookouts are not planned for manning until June 21. The fire weather records and the fire occurrence records show that detection service on the Snohomish County unit should begin about May 1 and sometimes earlier if the weather warrants. The State should arrange cooperatively with the Forest Service to man Pilchuck and French Point during the dangerous weather periods preceding June 21. The Forest Service plans to close these lookouts on September 10 unless the danger is too great at that time. The fire danger in late September and October may be high in the Snohomish County unit. Under such conditions Pilchuck and French Point should be manned for their value to the Snohomish County unit.

Records should be obtained, preferably using a haze meter, of the visibility distance from lookout points. Such a record would show the limit of visibility imposed each day by the smoke or haze in the atmosphere and might be an important factor in determining how many lookouts should be used.

Patrolman Detection

Since there are many roads in the high man-caused risk area south of Everett, automobile patrolmen are used for detection. This work can be done concurrently with law enforcement and prevention duties. The patrolman is usually depended upon to take the first suppression action on any fire he discovers or that is discovered and reported by the public. To speed up the reporting of fires by the public and the initial action and reinforcement on fires discovered by the patrolman he should have more frequent and quicker communication with his headquarters and the District Warden's headquarters. This could be obtained by the use of the portable radios now available for forest protection work.

In the other areas where patrolmen are used during a large part of the season quick action in reporting, dispatching, and sending reinforcements should be insured by having radio communication available when telephone facilities cannot be used quickly.

On days of severe fire weather and on days when visibility is poor extra patrolmen should be used. The warden should give each patrolman a definite patrol route plan which will specify the routes to be covered, the frequency of patrol during different classes of fire weather, and a schedule of contacts with the headquarters office.

Public Detection

A large proportion of the fires in this county are first discovered and reported by the public. The reliability of this detection service should be improved by keeping the public constantly aware of the necessity for reporting quickly any fires discovered. This might be done by posters and newspaper advertisements or notices put out annually. Probably many fires are seen by people who do not report them because they do not know where or how to report them or because there are not designated and convenient places for reporting along their course of travel. People usually will not retrace their route a considerable distance to some known reporting station, but if they should later see a clearly designated reporting station along their course they would stop and report the fire.

Communication

Facilities should be adequate to give direct communication between the District Warden and all lookouts having considerable seen area in the Snohomish County unit. Direct communication with all other wardens in or near the unit day or night should also be available for reporting fires or supervising fire suppression. This may require the use of radios in a few places as discussed under "Patrolman Detection."

4. TAKE IMMEDIATE SUPPRESSION ACTION ON EVERY FIRE AS SOON AS IT IS PHYSICALLY POSSIBLE TO PUT ONE OR MORE MEN TO WORK ON IT

Prompt and Strong Action Essential

Prompt action and strong action are accepted practices in fire control. Delays or weak action are not acceptable. Since it is possible that the State, the Association, private owners and operators and the Forest Service (along the common protection boundary between the Forest Service and the Snohomish County unit) may have certain jurisdiction, interests, and responsibilities in a fire depending upon the circumstances of its cause and location it is imperative that there shall be a clear understanding of the action to be taken on any fire. Advance planning and written instructions are necessary. If, as here maintained, prompt and strong action is basic to adequate fire control it seems that the very nature of forest fire behavior indicates that some one fully equipped, properly trained, ever vigilant, constantly ready organization must be assigned the job of taking such action. Therefore it is strongly recommended that the responsibility for initial action on all fires inside the Snohomish County unit be clearly vested

in the fire control agency operating in that unit. This would not prevent the fire control agency from delegating part of its responsibility to operators who maintain a special fire control service of their own when this appears to be the best way to get proper action.

The requirement that suppression action must be initiated promptly on all fires means that early season fires and late season fires must get adequate attention. The record shows (table 16) that April, May, and October fires have accounted for a considerable part of the burned acreage. All fires at any time should receive prompt attention. The only practicable way to take care of these early and late fires is to have adequate means of determining the existence of possibly dangerous fire weather, employ at least a skeleton organization for the full period that fires are likely to occur, and make provision to expand the organization whenever conditions become dangerous.

Placement of Men

Placement of men to provide the necessary speed of attack has been studied on the basis of fuel types, amount of area accessible with different travel times, and risk of fires starting. The following maximum travel times to each fuel type were used as a guide: "X" rate of spread, 10 minutes; "H" rate of spread, one-quarter hour; "M" rate of spread, one-half hour; "L" rate of spread, one to three hours.

The "H" rate of spread type south of Lake Roesiger should have a man within shorter travel time than Monroe or Granite Falls. The debris and hazard from cutting are great in this area and the amount of use makes the risk considerable. It is suggested that a man be placed in this vicinity. He should contact the users frequently and serve as a prevention as well as a suppression guard.

The other areas seem adequately covered by the present force.

5. MAKE A THOROUGH, SUSTAINED EFFORT TO STOP THE SPREAD OF ALL FIRES AS RAPIDLY AS POSSIBLE AND TO DO SUCH ADDITIONAL WORK AS WILL INSURE THAT THEY WILL NOT SPREAD AGAIN

As a general principle of forest fire control any fire on or threatening forest land at any time or place should be put out as soon as practicable after it is discovered. Exception is made for controlled fires burning under permit or for controlled fires which start when it is legal to burn without a permit. But even these fires should be put out whenever they get out of control or threaten to get out of control. The fire control agency should be ready and able during any month of the year to put out any fire that does not come under these exceptions. Halfway measures and gambling on the weather have no place in adequate fire control.

Prompt control of the fire following the initial action should be the first consideration. If shifting the responsibility onto those

legally responsible for the fire is causing delayed action or weak action it is a serious matter and calls for changes in fire control procedure. This is a problem that might very profitably be made the subject of further study. It is to be expected that the fire control agency will have better trained and more experienced men and more and better equipment than anyone else in its territory. It should be better able to fight a fire than anyone else. It should be instantly available and able to draw upon the men and equipment of adjacent units when necessary. The fire control agency should be given this strength, and it should be required to fight every fire. Once this procedure is established and properly financed it should not prevent the land owner or operator from also employing his full fire fighting resources.

It is appreciated that present procedures, such as the one requiring operators to fight their own fires, are the result of evolutionary processes and that each step in this development has probably been a step forward. It is also appreciated that present procedures are entangled with legal, financial, and administrative considerations and a considerable inertia. It might not be desirable to make any drastic or sudden changes. Such changes as are made should be backed by strong legal and financial support. Nevertheless it appears that if progress is to be made in solving the fire control problems of such forest lands as are represented in the Snohomish County unit the direction should be toward giving the fire control agency more complete responsibility and the legal and financial backing to meet its added responsibility.

The technique of fire control is well covered in various manuals and there is no need to develop that subject here. The indications are that the personnel in the unit handle fires in a skillful and effective manner. Adequate fire control demands that after the initial spread of a fire is checked aggressive action shall be taken to mop up the fire and prevent any further spread at any time. Mop-up is an expensive operation but experience has shown over and over again that it is a good investment. Therefore mop-up is emphasized here as one of the essentials of adequate fire control.

Fire Fighting Plans

More thought and attention should be given to advance plans for handling the large fire or critical fire situation that may occur once in several years. Most of the fires in the Snohomish County unit are handled by the regular employees and CCC crews. In case of emergency, possibly once in five or ten years when a fire reaches several thousand acres in size and other units need many CCC crews on large fires, it may be necessary to hire large crews in Snohomish County. Such an emergency, because it is infrequent, is liable to decrease the usual fire suppression efficiency of the county unit. The one emergency in ten years may cause greater expense than five ordinary years if it is allowed to get out of hand.

Before the beginning of each fire season the District Warden

should make a written memorandum of where he can hire men and obtain supplies for a 25-, 50-, 100-, and 400-man crew in case they are needed. For the small crews this memorandum should give the names of the men and how to reach them. For the larger crews the employment agencies and other sources need only be listed.

Sources for food, tools, and equipment should be listed and the amount each source can furnish on short notice. This should include all of the necessary fire fighting and camp equipment for 400 men. Trucks and drivers and pack horses available for hire should be listed with the quickest means of communicating with them. Equipment that can be borrowed from other county units, the Seattle headquarters of the Association, or the State Supervisor of Forestry should also be listed.

Rapid communication and shifting of attack are highly important on large fires. The portable radio for fire scouts, sector bosses and fire camps has proved indispensable for this purpose. At least four scout sets and one base camp set should be stocked at headquarters. When not needed for large fires these could be used by patrolmen for reporting fires on which quick reinforcement is needed.

Reliable local men who have the administrative ability and experience necessary for the job of equipping and managing a fire camp should be contacted each year before the fire season opens and should be given sufficient training in time keeping and other camp recording so that regular employees will not have to be used for these jobs. Most of the regular employees should be free to devote full time to fire fighting supervision. One regular employee should be trained to supervise the entire time keeping, camp, and property service for a large fire so as to leave the District Warden free from these details.

Other local men experienced in fire fighting and capable of acting either as strawbosses or in jobs of greater responsibility should be contacted before each fire season and should be given a training review to prevent the common errors that occur over and over on large fires. Foremen of logging and mill crews should be included. Wherever practicable this training of supervisory personnel should be done in groups so as to conserve the fire warden's time and stimulate discussion among the men. The training program should be outlined thoroughly and given considerable thought in advance. The men should be trained not only for their own job but should be given a list of the elementary things in which they in turn should train a green crew when they first reach the fire.

Recent experience indicates that a relatively small crew of experienced fire fighters in good physical condition, trained to work together, and with good leadership can often save a hot spot on a fire that would be lost by a much larger crew of ordinary fire fighters and might result in much greater acreage and line loss. It appears to be good management to have a crew of regular employees organized ahead of time from among the guards, patrolmen, etc. and if a fire develops

unusually fast-spreading sectors, to send this crew onto those sectors to check the spread but leaving the line-holding job to other crews who follow immediately behind the experienced crew. In such cases the regular employees may be more valuable as a fire fighting crew than if scattered out as foremen or strawbosses for other crews. Plans should be made to mobilize such crews and to build them up with personnel from other county units when needed. Plans should also be made to fill the positions when men are sent to fires. It is good practice to have two alternates trained and available for each position.

During fires that need to be fought for several days before they are checked the supervising personnel are liable to become physically and mentally exhausted unless relieved by other competent men. To insure that adequate supervision will be available as soon as needed on such fires written plans should be made before each fire season to draw upon the personnel of other county units. A list of the different supervisory jobs with the names of men from other units competent to fill each job should be made.

6. MAKE A CONSTANT EFFORT TO IMPROVE THE EFFICIENCY AND EFFECTIVENESS OF ALL FIRE CONTROL ACTIVITIES

Personnel

An alert, progressive spirit and the determination to succeed are essentials of adequate fire control. There is no place for complacent acceptance of things as they are. The personnel should be encouraged to develop new ideas and to try new methods and new equipment.

Employment of the warden and his assistant on a yearlong basis should be an important means of improving the efficiency of the organization. It would make these jobs attractive to trained, experienced men and reduce the turnover. The cost would be relatively small.

Men with a forest school education should be filtered into the organization to become wardens. Eventually the warden may have other duties than fire control which will require technical forestry training. Raise the importance of the warden's job and recruit, train, and hold good men to fill it.

Training

The older and more experienced employees should receive a short instruction and training course at the beginning of the season. At this time new methods, equipment, administrative procedures, and discussion of common errors should be included.

Before each fire season begins all new employees should be given a thorough and well planned course of instruction in fire suppression and fire protection administration and policy. Every effort should be made to give these men practical experience on the early season fires

so that they may be improved before the mid-season danger develops. The Chief Fire Warden of the Association and the State Supervisor of Forestry should cooperate in shifting men from one county where they can be spared to another where there is a large fire so that the training and experience of the men may be increased. A record should be kept of each man's performance so that his deficiencies may be recognized and reduced by specific instruction and training on future fires. This training program should be supervised by the Chief Fire Warden and the State Supervisor of Forestry.

All employees who may engage in slash disposal work should be given specific training for this job. Slash disposal can be important training as well as a means for prolonging the period of employment.

Use of Records

Fire records can be used to promote constant improvement in fire control. The value of complete records to the improvement of fire prevention activities has been mentioned. Records can be used as a training device and analyses can be made of them to determine what the specifications of adequate fire control should be. They can be used to determine the strong and weak points of current practices. To serve these various purposes every report on every fire should contain as much of the following information as it is possible to get and it should be accurate:

1. Location.

   Point where fire started.
   Map or other record of area burned.

2. Cause of fire. Record known causes; otherwise record as unknown.

   General cause--railroad, smoker, logging, etc.
   Specific cause--brake shoe, cigarette, sparks from donkey, etc.
   Person or class of people responsible.

3. Physical conditions.

   Relation of fire to seen area of lookout points.
   Visibility conditions at time fire was discovered.
   Fire danger--fuel moisture content and wind velocity at time fire was discovered and during its subsequent spread and control.
   Kind of fuel and fuel type.
   Topography.

4. Behavior of the fire.

   What was fire doing when first man arrived--smouldering, creeping, running, spotting, or crowning?
   Amount of spread during period of control work.

5. Action and time record.

Time of origin if known.
Time of discovery and name of discoverer.
Time report was received and name of receiver.
Time of first attack and name.
Time reinforcements arrived and names.
Time the spread of fire was stopped.
Time the fire was out.
Name of individual or agency actually responsible for fire control action.
Total number of man hours worked.
Distances traveled for initial attack and method of travel.

6. Damage.

Ownership of land burned.
Map or other record to show area burned by cover types.
Amount of timber, reproduction, etc. killed. Use Forest Survey types or combinations of them.
Value of damage in dollars.
Other effects of the fire such as erosion, loss of recreation values, etc.

7. Other information. A brief narrative should accompany all fire reports where needed to give a complete account of the circumstances of the fire.

7. PROVIDE STRONG, FLEXIBLE FINANCIAL SUPPORT

One of the most important ways to attain adequate forest fire control is through the development of strong, flexible financial support. One of the outstanding characteristics of fire control is the extreme variability in the work load and costs from year to year. Even the length and intensity of the fire season and the activity of fire starting agencies vary markedly from year to year. Therefore a budget based on average costs for overhead, temporary employees, prevention and presuppression will not meet the needs of years that are above average in length of season, fire danger, or number of fires. But even more serious is the fact that fire suppression costs vary tremendously from year to year. One year the regular force may be able to put out all fires without any extra fire fighting cost; another year thousands of dollars of extra fire fighting money may be required. These unpredictable, above average fire fighting costs embarrass a fire control agency that depends on a fixed annual income based on average costs. If it is unable to pay these costs fire control action may break down and loss and damage will mount.

There are several ways in which flexible financial support can be provided for fire control agencies. The Forest Service depends on a deficiency appropriation to meet its unpredictable costs. State

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agencies might do the same unless prevented by statutory limitations. Under the fire patrol assessment laws the amount of the assessment can be varied according to needs up to a fixed limit. Budgeting several fire control units under one coverage may help to distribute small variations in each unit if the coverage is sufficiently wide so that costs do not rise in all units at the same time. Reasonable reserves might be accumulated to be used as a revolving fund to meet the above average costs.

Another method of meeting these unpredictable, above average costs that has been used by the Oregon Forest Fire Association makes use of the insurance principle. Arrangements are made for the fire control agency to purchase insurance which provides that fire fighting costs between certain upper and lower limits will be paid in part or entirely by the insurer. A definite, predictable annual payment in the budget can be related to fixed annual income and go a long way toward paying unpredictable fire fighting costs. The annual cost is dependent upon the past experience and can be adjusted up or down according to future experience. Since the annual cost is based on experience it is to the advantage of the fire control agency to keep fire fighting costs as low as possible, and this tends to offset any tendency to spend too freely. By this method the average cost tends to become the total cost of fire control, and adequate action can be taken to meet almost any situation likely to develop.

The various methods for meeting the above average costs which have been mentioned if properly administered should not increase the average cost because their only purpose is to make money available when it is needed. A fixed budget based on average costs cannot meet the peak loads included in the average. In fact, being able to meet the peak loads in an adequate manner might very reasonably be expected to lower the average costs because the peak loads are an extremely important item in determining the average cost of adequate fire control.

If it is highly important for the fire control agency to have strong, flexible financial arrangements to meet the obligations which have been delegated to it by the land owners and the State it is equally important for the land owners, logging operators, contractors, etc. who have fire control liabilities which they have not or cannot delegate to be similarly financed. (Fires or responsibilities for which the fire control agency is not responsible are usually called operators' fires or responsibilities and this terminology will be used here.) The present laws make the operator legally responsible but they do not help him to finance his responsibility nor insist that it must be properly financed in advance. In meeting his responsibility for fire control in an adequate manner the operator may be confronted with costs that have no relation to his wealth. It may cost $5,000 to adequately fight a given slash fire whether the responsible operator is bankrupt or worth millions.

The law does provide that the fire control agency can take action and recover costs from the operator, but this does not finance the

fire fighting job unless the operator has assets that can be turned into cash. Taking his lands or other properties does not provide the fire control agency with cash. All too often the cost of the adequate control of an operator's fire exceeds his total assets.

Therefore, placement of fire control responsibility on the operator makes adequate fire control an impossibility unless he can finance his obligations. This is especially true because operators' fires commonly burn in logging slash, which is the most dangerous fuel. At present operators who are financially weak are made responsible for fire fighting action the cost of which they cannot possibly meet except by spreading the cost in advance by means of a bonding or insurance arrangement which can be financed as a part of their operating expense. If every operator were given an opportunity and required by law to make adequate advance preparation to meet his fire control liabilities it would tend to make his average annual operating cost his total cost and he could take strong, aggressive action in any fire situation that might develop. If he should decide to delegate all the fire fighting to the fire control agency he could pay the cost. If all the operators had their fire fighting liability financed in some such manner as this it would largely do away with the present tendency to shift responsibility back and forth between the fire control agency and the operator, which may result in ineffective fire control and increase the losses sustained.

The very nature of fire control requires a strong, flexible budget and special advance preparation must be made to meet above average costs, especially fire fighting costs. In order to obtain adequate fire control under the present pattern of division of responsibility between the fire control agency and operators, both parties to this arrangement must be adequately financed to meet their liabilities.

COST OF ADEQUATE FIRE CONTROL

The estimate of the cost of adequate fire control in the Snohomish County unit is based on the following general specifications:

1. All managed and unmanaged forest lands in the four land use districts of the present unit will be protected.

2. The seven specifications of adequate fire control developed in this plan will be applied to the unit.

3. The fire control agency will take prompt and strong action on all fires regardless of the responsibility of the land owner or operator. In addition, the owner or operator will be required to do all that he can to help, especially on fires on industrial operations. (Recoverable fire fighting costs will be collected; therefore, the estimate does not include fire fighting costs which may be collected.)

4. Total annual costs of adequate fire control are estimated from

this time forward with no charge for present improvements. The value of the future CCC contribution has been included by making a conservative estimate of the cost of replacing them. The various sources of the money to meet these total costs are not indicated. The costs of special camp wardens, watchmen, railroad patrolmen, and fire fighting and slash disposal on private operations are not included because it is assumed that they will be paid by the operator as at present.

5. The headquarters of the unit will be located at a central point such as Everett.

Costs are estimated on the basis of these specifications in table 26.

Table 26.--Itemized estimate of average annual cost

Item number	Item	Estimated annual cost
1	Warden's salary - 12 months	$ 2,400
2	Assistant warden - 12 months	1,800
3	Assistant warden - 8 months	1,200
4	Headquarters man - 6 months	720
5	Travel expenses for above men	3,000
6	4 patrolmen, lookouts, etc. - 6 months at $120	2,880
7	6 patrolmen, lookouts, etc. - 5 months at $120	3,600
8	7 patrolmen, lookouts, etc. - 3 months at $120	2,520
9	Extra men during periods of most extreme fire weather	500
10	Car or travel expenses for patrolmen, etc.	1,000
11	Value of detection service contributed by other units	500
12	Equipment including tank trucks, trucks, tractors, pumps, hose, hand tools, radios, fire danger instruments, etc.	7,000
13	5 operators for trucks, tractors, pumps, etc. - 4 mo. at $120	2,400
14	Stand-by crews for fast initial action on fires - 20 men at $100 per man for 2 months	4,000
15	Fire fighting - cumulative fund for extra costs, not recoverable	5,000
16	Fire fighting - insurance to cover large costs	1,000
17	Improvements including maintenance	7,000
18	Share State-wide organizations	3,000
19	Overhead - State inspection and law enforcement	3,000
20	Miscellaneous local expense - rent, office expense, etc.	1,000
	Total	$53,520

Explanation of items in the cost estimate

Items 1 and 2. Provide two yearlong men for general administration, fire fighting supervision, inspection, law enforcement, prevention, and training of subordinates.

Item 3. Additional man of warden caliber to share part of load during fire season.

Item 4. Man to act as dispatcher, custodian of equipment, write burning permits and keep records and prepare reports during months of heaviest load.

Item 5. Travel expenses including automobile travel cost for private cars or for cars owned by the fire control agency.

Items 6, 7, 8. Patrolmen and lookouts, hired each year for periods of dangerous fire weather with sufficient time allowed for training.

Item 9. Special patrolmen and lookouts hired to strengthen organization during periods of most extreme fire danger. Time allowed for training.

Item 10. Self-explanatory.

Item 11. Value of detection service given to the unit by Forest Service lookouts and lookouts in adjacent units above the value given in exchange by the Snohomish unit.

Item 12. All equipment items were estimated on the basis of per-year cost including depreciation, operation and maintenance. Three tank trucks, one light tractor for line building and one truck to haul it and two trucks to haul stand-by crews were included in the estimate as well as allowance for pumps, hose, hand tools, radios, fire danger instruments, etc. ($2,000 represents replacement value of CCC contribution.)

Item 13. Provides five operators for equipment that cannot be effectively operated by other employees. ($1,000 represents replacement value of CCC's.)

Item 14. Would provide wages and board for two 10-man crews (or one 20-man crew) to be on instant call for fire fighting during dangerous fire weather. At other times they might be working on improvements and paid from improvement funds. ($3,000 of this item can be considered as replacement value of CCC's.)

Item 15. Includes special or extra fire fighting costs only. Men or equipment listed in above items and used in fighting fires does not add to this cost. Extra men or equipment hired to work on a fire

or other expenses incurred on fires are proper charges against this item. The estimate is an average annual cost. The cost will vary greatly from year to year and this variation must be met by accumulating balances and free exchange of funds between units in emergencies. Recoverable costs of fighting fires on lands where the owner is legally responsible are not included. Includes an estimate of $3,000 as the replacement value of CCC fire fighting.

Item 16. Estimated annual cost of insurance (or equivalent) whereby the fire control agency would be protected in meeting fire fighting costs above some specified amount. Would enable fire control agency to continue strong action on a large fire or a series of large fires where fire fighting costs might mount to sums too large for the annual budget.

Item 17. Includes cost of maintaining improvements constructed by the CCC in the past and future construction of improvements whether by CCC or otherwise. (Includes $5,000 as replacement value of CCC contribution.)

Item 18. The unit's share of the cost of its parent organizations (State and Association). Includes all services and costs of the parent organizations that the unit must share. Adequate fire control in this unit assumes adequate functioning of its parent organizations, which would give more service and therefore cost more than at present.

Item 19. Cost of inspection and law enforcement service furnished by the State to the unit.

Item 20. Miscellaneous expenses of the unit such as rent, light, commercial telephone, etc.

It will be noted that the total estimated replacement value of the CCC's in items 12, 13, 14, 15, and 17 amounts to $14,000. This does not mean that the present CCC work in the unit is worth no more than this amount per year. The $14,000 is intended as a conservative estimate of the minimum amount required to replace the CCC's in the unit under a program of adequate fire control.

Cost per Acre of Adequate Fire Control

Before translating these estimates into costs per acre it is necessary to point out that the total expense for fire control in the unit is divided among the private owners, the State and the Federal government. Therefore, the present Association assessments or tax roll rates do not represent the total cost of fire control on the private lands or an average per-acre cost on all lands. Starting with the total estimated annual cost of $53,520 for adequate fire control from table 26 and subtracting the $14,000 included as the minimum replacement value of the CCC, which is a Federal share of the cost, and subtracting the $6,000 included as a forecast of the share of the total

cost that might be charged as State-wide overhead, there remains $33,520 to be met by the land owners or a total cost of about 6 cents per acre against all the 546,000 acres of forest land, public and private, in the unit. If it can be assumed that the State and Federal governments will pay the per-acre costs of fire control on their lands in addition to the $14,000 and $6,000 mentioned above and that all other forest lands will pay their share, adequate fire control could be obtained for 6 cents per acre.

It must be clearly indicated by this time that the direct cost of adequate fire control to the private owner depends in large measure upon how fire control on the State, Federal, and non-paying lands is financed. If all the $53,520 were charged against the 546,000 acres of forest land it would cost 9.8 cents per acre per year. Therefore, 9.8 cents per acre may be considered the basic cost of adequate fire control spread over all forest lands in the unit. If the same total cost must be met by the private, State, and Federal lands totaling 322,000 acres now paying for fire control it would cost them 16.6 cents per acre per year. If the State and Federal governments pay $20,000 of these costs to protect forest values on all lands a rate of 6 cents per acre on all lands would meet the remainder of the cost of adequate fire control, as indicated above; however, if it must be assumed that the present 224,000 acres of non-paying land will continue to make no direct payment for fire control, then the cost to the present paying lands would be 10 cents per acre instead of 6 cents. Therefore, under present conditions adequate fire control would cost the land owners 10 cents per acre and this figure can be compared with what they are paying.

These figures call attention again to the important part the State and Federal share of the cost and the 224,000 acres of non-paying forest lands, which are mostly tax delinquent, county owned, or non-paying because of residence exemption, have in determining the cost per acre to be paid by the paying lands in the unit.

It is not to be expected that the above cost estimates will be accepted as final. They are intended as a specific example of what adequate fire control might cost. In addition, there are several intangibles that cannot be appraised in dollars; for example, the personal element. One man or group of men might be able to accomplish much more than another at the same cost. Fire control also battles against natural forces whose effect varies tremendously from year to year. The cost of adequate fire control in an exceptional year like 1910 will be very different from the cost in the most favorable years. It is as impossible to forecast needs as it is to forecast the performance of people. Nevertheless the above cost estimates will serve their purpose if they indicate the approximate level of fire control effort and expenditures required to obtain adequate fire control for the sample unit.

It may not be equitable to spread the cost equally against all forest land in the four land use districts. The analysis indicated (table 22) that 76 percent of the total cost of fire control was spent in the combined virgin forest and cut-over districts. On this basis,

the $33,520 might be raised by charging 7.2 cents per acre against the 354,650 acres of forest land in the virgin forest and cut-over districts and 4.2 cents per acre against the 191,380 acres of forest land in the agricultural and rural residential districts. However, the specifications herein set forth would probably increase the intensity and the cost of fire control in the agricultural and rural residential districts more than in the remainder of the unit, so that it might be reasonable to distribute the total cost equally against all forest lands in all four districts.

There are other possible methods of distributing the costs of fire control against the property protected. The distribution according to acreage without consideration of values, risks, or hazards has been used in the examples presented because it is in effect at the present time. Use of this method in the examples does not constitute a recommendation for its continuance. On the contrary, it appears that this method is unsatisfactory and that a more equitable method should be found which would distribute the costs of fire control in proportion to all the values protected with some consideration of risks and hazards.

The cost of adequate fire control might be reduced by giving the warden and his assistants other duties in addition to forest fire control. If the same personnel and equipment were used to protect buildings and other properties and the costs of this service were paid from general taxation there would be a reduction in the overhead cost of forest fire control. If the whole field of forestry instead of the field of fire control alone were assigned to the organization considerable forestry work could be accomplished with the same expenditure of money, with a compensating saving to fire control costs. A portion of such items as yearlong salaries, equipment, and improvements might be used for other forestry projects than fire control in such a manner as to reduce costs without in any way weakening fire control.

CONCLUSIONS

Although the techniques of fire control are important and must be applied skillfully, they do not present any real obstacle. Evidently, in the Snohomish County unit, a good job is being done within the limits of the resources at the disposal of the fire control agencies, considering the conditions under which they work.

There is urgent need for additional supervisory and technical personnel employed yearlong to strengthen all phases of fire control in the unit, especially law enforcement, prevention, training, and records.

Adequate fire control will not be attained until private and public land owners see greater value in their forest lands than they do at present as evidenced by the large acreage of forest land that is

unmanaged, tax delinquent, not paying for or inadequately supporting fire control.

All forest lands of all ownerships should be required to support fire control.

Some provision should be made whereby all land owners or operators who are liable for fire fighting or hazard reduction expenses can make advance financial arrangements which will enable them to pay these costs.

The fire control agency should be provided with a flexible budget or with reserve funds in order that it can handle above average fire loads.

The fire control agency should be responsible for prompt, strong action on all fires without lessening the fire control action or the legal or financial obligations of the land owners or operators.